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FORTY-FIFTH
INDIAN SCIENCE CONGRESS
MADRAS

Brochure

ON

GROWTH OF SCIENCE AND SCIENTIFIC EDUCATION IN SOUTH INDIA

UNIVERSITY OF MADRAS
1958

G. S. PRESS, MADRAS

FOREWORD

At the invitation of the University of Madras, the Indian Science Congress is holding its 45th Session in January next. In this connection, the Reception Committee has brought out a special publication which may be of some interest and of use to the delegates attending this Congress.

To the scientists, India must always present picturesque problems, both from the pre-historic and historic points of view and from the point of view of the natural resources, and customs and manners of the people inhabiting this vast sub-continent. South India has its own special features, and it welcomes the great savants in science after many years, meeting once more in the capital of the State of Madras.

Thanks to the enlightened interest taken by the Prime Minister of India and the support extended to the Congress from scientists abroad, this session would be of interest to all the delegates. It is hoped that this publication will be of service to them, and help them to know something of the South.

A L Mudaliar

Vice-Chancellor, University of Madras

ABOUT THE BROCHURE

The Forty-fifth Session of the Indian Science Congress is being held in Madras after a lapse of seventeen years. When it last met in 1940 with dark war clouds of World War II hanging gloomily and gathering momentum, science had not progressed as rapidly as it has during the post-war years. The size of the Indian Science Congress too has grown to phenomenal dimensions and today we have more than two thousand five hundred ordinary members and over five hundred sessional members. What, indeed, does all this indicate? It is the unmistakable sign of a passion for new knowledge and the faith of the Indian people in science and all that science stands for in the service of man The invitation for the Forty-Fifth Session to be held in this University had come from a distinguished educationist, gynaecologist, Vice-Chancellor and President-elect for the 46th Session of the Indian Science Congress, Dr. A. L. Mudaliar, and this, therefore, adds a special significance to the invitation.

Almost the first decision taken at a meeting of teachers of this University and our Vice-Chancellor was that of bringing out a Brochure on the growth of science in Southern India for the occasion. For over a century we believe we have steadily built healthy traditions in teaching of the humanities. Teaching and research in science and technology, however, is somewhat recent but yet we have today many pioneering efforts in these newer fields in many university and research centres in peninsular India. The Brochure, as our Vice-Chancellor defined it, was to contain relevant matter on the history of development of teaching at the post-graduate level in the various institutions in Southern India together with immediate development programmes. The compilation of such a publication is, we admit, an extremely difficult task in the short time at our disposal but we embarked on it and what we have presented here is the fruit of the efforts of many colleagues. Professors G. D. Boaz, Bertie A. D'Souza, U. R. Ehrenfels, V. S. Jayaraman, G. Krishnan, V. S. Krishnan, A. P. Madhavan Nair, P. R. J. Naidu, K. C. Naik, D. V. Rajalakshman, P. S. Sarma, C. V. Subramanian, M. A. Thangaraj and Florence Theophilus acted as convenors of the various sections presented here and I must say that the readiness with which they attended to various aspects of presentation of data collected over a vast region has left me in a deep debt of gratitude. We have also received much help and cooperation from Shri K. N. Sundaram, Assistant Educational Adviser, Southern region. My special thanks are due to my colleague Prof. George Kuriyan for many useful suggestions in bringing out this volume. In the fitness of things I have to record our indebtedness to the many scientists in sister universities and research laboratories in this part of India for valuable material which form the bulwark of this compilation and I do so with pleasure.

The tempo of scientific research in many of the scientifically advanced countries has reached a terrific pitch and I can do no better than to recall our Prime Minister's reactions to the launching of Sputnik I into outer space: "I cannot help thinking that the more we advance in the field of Science, the less we seem to progress in the field of civilization". It is precisely this balance in outlook that we are feverishly trying to build in new India and in presenting this small Brochure we are conscious of the headway we have to make if we are to catch up with Western scientific progress.

I may be permitted to quote before dedicating this Brochure to the 45th Indian Science Congress the very significant words of that great savant of this century, Albert Einstein: "I do not intend to argue with you about what inroads on human liberty may be justified by reasons of State. But the pursuit of scientific truth, detached from the practical interests of everyday life, ought to be treated as sacred by every government, and it is in the highest interests of all that honest servants of truth should be left in peace".

University Botany
Laboratory, Madras.

T. S. SADASIVAN

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AGRICULTURE

Agricultural Education had its beginning in Madras in the year 1876 when an Agricultural College was established at Saidapet. The objective of the College was to create a class of men who would go back to their lands and carry out the improved methods of farming that was sought to be attained by carrying out cultural, varietal and manurial experiments, by introduction of new implements and improving the livestock by stock breeding experiments.

The next step was in 1904 when under the driving force of Lord Curzon far reaching changes of policy were made in the organization of agricultural departments all over India. The new policy laid a rightful emphasis on the interdependence of research, education and demonstration in all schemes designed for the uplift of the farming population and the agricultural departments all over India were reorganized on this basis.

In pursuance of this policy the Agricultural College and Research Institute, Coimbatore was built in 1909. The first batch of students was selected in 1908 itself and the students were taught agriculture and allied subjects both practical and theoretical leading up to the "Diploma in Agriculture". But the syllabus was too elaborate for such of the students who desired agricultural education merely for farming their own lands. Hence in 1914 the course was modified by having two courses, one an exclusively practical course lasting two years known as 'Certificate of proficiency in Agriculture' and the other an extension course of another 18 months leading to the 'Diploma in Agriculture', for a picked few from amongst the certificate holders. By 1920, yet another change was made when the college was affiliated to the University of Madras and the Diploma course replaced by the B.Sc. degree in Agriculture, with Intermediate in Science fixed as the minimum entrance qualification. In 1926, along with the Golden Jubilee of agricultural education in Madras the number of admissions was raised to 48 from the original 20. In the extensive Central Farm and the various crop breeding stations excellent facilities are provided for the students to learn all the practical aspects of agriculture. The three year degree course imparts instruction of a high standard in Agriculture and its allied sciences and is considered as one of the best in India. The admissions to the College were raised from 48 to 96 in 1944 and to 108 from 1954 and to 162 since 1956 to provide trained hands to man the numerous projects and schemes programmed under the Five Year Plan. In 1953-54 the regulations were revised to provide for a training period of six months during the third year of the course. So far 1,548 agricultural graduates have passed out of the College from the inception of the degree course in 1921.

In the year 1933 the University of Madras recognized that the facilities available in this Institute were adequate for the students to qualify themselves by research work for the M.Sc. and Ph.D. degrees of the Madras University. Several theses have since then been submitted. At present nearly fifty candidates have registered for research degrees (Ph.D. and M.Sc.) from this institution.

A post-graduate Diploma course in Horticulture was instituted departmentally in the year 1949. This was affiliated to the Madras University from the academic year 1953-54.

A refresher course in Agriculture started in 1953 caters to about 30 young farmers every year. Another course for training gardeners has been started this year to give intensive practical training in maintenance of gardens and orchards.

Agricultural Research in Madras:

Agronomy: The Research Institute had its beginning with just three divisions, viz., Agriculture, Economic Botany and Agricultural Chemistry. Research on agronomic problems were undertaken ever since the inception of the College and Research Institute. The growing importance of Agronomy as a primary science in agricultural improvement was recognized and as a result a separate Agronomy Section was organized in 1952. Agronomic research in the early period led to the introduction of labour-saving implements and proper method of preserving cattle manure. During recent years study of the long range effects of crop rotations and the effect of tillage, manures and irrigation on different crops have gained importance. The investigations on the agronomic problems of the Thungabadra irrigation project has clearly brought out the relationship between sowing time to yields and it was possible to fix the type of crops to be grown and requirement of manures in the area for each crop. Schemes financed by the Indian Council of Agricultural Research were in operation in Hagari to study various aspects of dry farming in the area. As a result of the study over a long period the benefits of contour bunding to reduce soil erosion and methods of soil moisture conservation, optimum manurial requirements, type and method of cultivation have been worked out to raise crops to the economic advantage of the cultivator.

A sub-section of Agricultural Meteorology was newly created for investigations on crop weather relationships to assess and in due course to predict the influence of weather and seasonal conditions on crops and issue warnings against cyclones, droughts and to forecast incidence of pests and diseases in epidemic form.

Agricultural Botany: The Madras Herbarium attached to the Botany Section offers unrivalled facilities for study and research in systematic botany and has one of the best collections in India with over two lakhs of specimens including many rare collections. The centenary of the herbarium was celebrated in 1954. Regional surveys of each district have been taken up in systematic botany to assess the plant wealth and to utilize useful plants for pastures, manures and soil conservation. The attached Botanic Garden forms a testing centre for new plant introductions. The section has published over 200 papers on various fundamental and economic aspects. Among the books published from this section, "South Indian Bananas", "Grasses of South India", "Text book on Botany" and "Text book of Cytogenetics" may be mentioned. In addition to the teaching of Agricultural Botany to the students of B.Sc. (Agriculture) degree course, the section affords facilities and guidance to post-graduate workers for M.Sc. and Ph.D. degrees of the Madras University.

Plant Physiology: A sub-section in Plant Physiology was opened in 1946. Research work done in this division was directed to study the effect of pre-treatment of seeds to improve yields in several crops and also to rectify nutrient deficiencies where they happen to exist in certain soils. Pre-soaking paddy seeds in 20 ppm solution of the growth hormone indole acetic acid was found to increase the grain yield by about 18%. Potatoes were capable of yielding 30% more when the same treatment was adopted. Vernalisation studies on rice indicated that a good deal of varietal difference exists even in the same crop. It was also noted that vernalisation was likely to be more useful as a means of improving grain yield in rice than for reducing the duration. In the case of responsive varieties the yields were increased by 12 to 38% over controls. As a result of micro-element nutrition study it was noticed that paddy plants sprayed with suitable solutions of copper, zinc and manganese sulphates about a month after transplanting improved the yields by 24% over unsprayed controls. Soil dressings with Borax at 40 lb. per acre applied a month before planting improved sweet potato yields by about 24% and that of lucerne by about 10%.

Cytogenetics: Cytogenetics sub-section in this Institute was opened in 1946 to study the chromosome numbers and cytogenetic studies on economic plants, to analyse inter-specific and other wider crosses to create amphidiploids and to obtain useful re-combinations of plant characters, to induce polyploids and gene-mutations. In *Pennisetums* it was found that the wild types are totally different from the cultivated types and do not hybridize with them. Among cultivated types *Cumbu* (*Pennisetum typhoides*) is a diploid and Napier grass (*Pennisetum purpureum*) is an autopolyploid. It was possible to secure a set of perennial, high yielding fodder plants by crossing these two species. Recently similar interspecific crosses in *Sorghum* resulted in a profuse tillering type of fertile grain yielding, 40 chromosome sorghum.

Agricultural Chemistry:

Study of soils, their origin and properties and fertility problem form a part of the work of this section. Soil surveys were undertaken in the earlier years in deltaic tracts to assess the manurial requirements of each tract separately. As a result of this type of survey, it was possible to recommend type and amount of manure required for cultivation in the different tracts. The soils in all the areas were found to be deficient in organic matter, nitrogen and phosphorus. Soil surveys were carried out in later years in Tungabhadra project, Cauvery-Mettur project, Lower Bhavani project, Gundalakkamma project, Toludur project, Gandikotta project, Bhairavanitippa project and for fruit development in the Ceded districts and cyclone affected areas in North-eastern coast of Madras. It was possible to indicate the type of crop to be grown, methods of irrigation, manuring and cultural practices to be adopted in these tracts for successful and economic cultivation of crops.

As a result of intensive trials the problems of reclaiming alkaline and saline lands were made possible. Another achievement of this section is the introduction of seed inoculation in leguminous crops prior to sowing with the right kind of root nodule bacterial cultures to improve the yield by 10 — 30%. The section is engaged at present in standardization of rapid soil test technique and tissue test technique for speeding up advisory work on manurial requirement of soils, chromatographic techniques, new types of nitrogenous and phosphatic fertilizers and improved methods of compost making.

Plant breeding and crop improvement:

Rice: In 1913 a separate Paddy Breeding Station was started at Coimbatore. In course of time several sub-stations sprang up to tackle the problems on a regional basis. An exhaustive study of morphological peculiarities, growth, anthesis and genetics was made. "Basumathi" from the Uttar Pradesh and SR26B from Orissa were successfully introduced in Madras. A number of collections of rice were made and at present there is a collection of more than 2,300 varieties in 12 species of *Oryza*. Hybridization work was commenced in rice in 1917 in view of its wider scope and greater possibilities for combining desired economic characters from different varieties. As a result of pure line progeny selection over a number of years 113 improved strains have been evolved so far. The periodic occurrence of a serious disease "Paddy Blast" and the heavy damage it caused necessitated the evolution of blast resistant strains suited for the different rice growing areas. The highly blast resistant quality of Co. 4 was utilized for breeding resistant strains such as Co. 25, Co. 26 and ADT. 25. Fineness of grain and the requisite degree of seed dormancy has been successfully combined in a short duration strain TKM. 6. Another achievement is Co. 14, a flood resistant variety, evolved after careful hybridization and selection. By X-ray and chemical treatment mutations were induced in the strains GEB. 24 and Co. 13. The mutants were profusely tillering with non-lodging habit and yield 30% more than the parents.

Millets: The Millets Section was started in 1923. The earlier years were marked for the fundamental studies to gain basic knowledge on the various plant characters and their genetic interrelations. As a result about 113 research papers have been published so far. Twenty-two improved strains of sorghum have been evolved as a result of knowledge gained in the basic studies.

Sorghum halepense one of the progenitors of cultivated sorghums is highly resistant to drought. Attempts to hybridize this wild type with cultivated sorghums failed due to the difference in chromosome numbers in both. Recently a successful fertile cross has been obtained which has great potentialities in evolving highly drought resistant strains. Co. 18 a new strain evolved has both high grain yield and juicy stalks so that it will serve as a dual purpose strain. "Bangainhilo" a highly *Striga* resistant variety from Africa was successfully utilized to breed a *Striga* resistant cholam suited to Madras conditions.

Cumbu (*Pennisetum typhoides*) being a normally cross pollinated crop, it is not feasible to evolve high yielding pure-line selections. So crop improvement in *cumbu* was sought by practical utilization of hybrid vigour as was done in the U.S.A. in the case of maize. High percentage of natural cross pollination was obtained by sowing the parents in adjacent rows two links apart and also by mixing the seeds of the two parents in the same row in the proportion of one female to three male parents. Two hybrids X_1 and X_2 thus evolved were found to give an average increase in yield of 40% over the local varieties.

Cotton: Research on cotton was started in the year 1920 for the improvement of Cambodia cotton at the Anamalais Farm. The centre was shifted to Coimbatore during 1923. In due course substations were started to solve local problems in cotton improvement to meet the needs of particular tracts. In 1929 the first improved strain Co. 2 was released. Though this strain had very desirable features its long duration was a handicap for its wider spread. An improved strain MCU. 1 was, therefore, evolved and released in 1950. This strain has now spread extensively. Yet another strain MCU. 2 was evolved recently from a multiple cross involving Co. 2, East African types and Sea Island cottons as parents. This strain is superior to MCU. 1 in longer staple length, yielding 10% more of lint per acre and spinning upto 52 counts. Its duration is also 15 days shorter than MCU. 1 and is suited for summer Cambodia areas.

In the Tanjore delta the possibility of growing the variety $P_2$16F in rice fallows in summer has been explored. Trial of perennial types indicated the suitability of "Moco" and "Quebrandinho" for homestead and backyard cultivation. In the West Coast long staple types of Sea Island cottons were successfully introduced.

Work on hybrid material from *Gossypium arboreum, G. indicum* and *G. cernuum* led to the evolution of two superior high yielding strains K2 and K5 suitable for the Southern and Central districts of the State. The unification of the Desi cotton areas—with a cosmopolitan strain is an accomplished fact with the release of the K5 strain. Many schemes financed by the Indian Central Cotton Committee are in progress to intensify the programme of hybridization. In addition to pure line selection and hybridization, polyploidy and distant hybridization involving wild cottons are adopted in the present work.

Oilseeds: The Oilseeds Section was started in the year 1930. Since its inception several improved strains in Groundnut, Castor, and Gingelly have been evolved by selection and hybridization.

Horticulture :

Fruit research was started in this State in 1871 when the Burliar fruit station came into existence followed by a station at Kallar in 1900. Both the stations were intended to find out the varieties of fruits, spices and other horticultural crops of economic value that can best be grown in lower elevations under humid tropical conditions. The Coonoor fruit station started in 1920 paid attention to the temperate fruits. The importance of research on fruits grown in the plains led to the opening of the Kodur fruit station in 1935. A separate horticultural section was founded in 1941. This section has succeeded in introducing and acclimatizing a large number of exotic fruits and evolving many useful improved horticultural practices.

Sugarcane :

Indigenous varieties of sugarcane were cultivated till about the nineties of the last century. When "Red rot", a devastating fungus disease, threatened the crop in the Godavari district, exotic types like Mauritius, Java Hebbal, POJ 2878, Fiji B, etc., were imported from other countries which helped to tide over the crisis. At this stage the Indian Sugarcane Breeding Institute came into existence and took up the work of evolving suitable varieties for the different regions in India. The Coimbatore varieties are all developed from seeds set by open or cross pollination deliberately planned.

Plant Pathology and Mycology :

The investigations of the major diseases of Rice has been an important item of work attended to by this section. Hundreds of paddy cultures were tested for blast resistance and three hybrid cultures Co. 25, Co. 26 and ADT. 25 were released as resistant strains. Paddy strains GEB. 24 and PTB. 7 were found to show a high degree of resistance to foot rot disease of paddy. Seed treatment with organo-mercury fungicides like Agrosan GN. or Ceresan were found to control the disease. Grain smut of sorghum, damping off of chillies, vegetables, tobacco, die-back and fruit rot of chillies, bud rot of palms, stem bleeding of coconut, Mahali disease of arecanut, red rot and smut of sugarcane and coffee rust are some of the other diseases that were studied and control measures worked out to check them.

Spraying schedules were worked out to control Mahali disease of areca palms and diseases of grapevine. The problem of decline in Mandarin oranges was studied and remedial methods were suggested.

An important achievement of this section is the production of ergot on a large scale in the Nilgiris. By continuous selection the quality of ergot has been improved and Nilgiris ergot is claimed to be one of the best in the world in quality.

This section is also engaged in teaching the subject to B.Sc. (Ag.) students.

Agricultural Entomology :

Entomological work was started in the year 1906 under the control of the Economic Botanist and in 1912 a separate section was started under a Government Entomologist. Valuable collection of South Indian insects has been built up and a number of new species have been described. Substantial work has been done on Braconidae, Thysanoptera, Coccidae, Curculionidae, Cecidomydae, Acarina etc. Bionomics of insect pests and control of crop pests were studied. Improvement of fumigation technique led to the control of stored product pests. In the field of biological control outstanding success has been achieved in the control of *Nephantis serinopa* by its hymenopterous parasite and of the obnoxious prickly pear by the coccid *Dactylopins tomentosus.*

Bee keeping studies are in progress to increase the yield and improve the quality of honey. The Entomology section is also engaged in teaching agricultural zoology and economic entomology to the students of B.Sc. (Ag.) degree course.

Agricultural Engineering:

Till 1927 this section was engaged only in teaching agricultural engineering to B.Sc. (Ag.) students, In 1927 a separate research section was constituted. In 1931 suitable workshop facilities were developed to design new and improved types of agricultural implements.

A double mould board ridge plough, a single bullock harness, turmeric polisher, pedal operated groundnut decorticator, are some of the products of this section. Coir rope filter point is a cheap and outstanding achievement in agricultural engineering design by this section.

MYSORE

Crop improvement in Mysore has been attempted by evolving hybrid varieties to improve yields. Many paddy hybrids have been evolved and are under study. A few crosses have been made to get drought resistant varieties. American sorghums introduced were found promising regarding yield and being early in duration escape the drought that sets in at the end of the season. Three red gram strains and seven strains in groundnut were selected with high yield and good qualities for cultivation by ryots. Under the auspices of the Indian Central Cotton Committee, Cambodia cotton breeding scheme was in operation to evolve suitable long staple American cottons for Tungabhadra project area and for the rainfed area of the Ceded districts. Kariff plantings show that the early season resulted in higher incidence of red leaf disease. The late seasons crop suffered from pests. Mid August sowing has been found to be the best for sowing. MAII a Mysore cotton evolved was found suited in earliness and found resistant to jassids. Small scale trials are in progress to find out suitable early maturing cotton variety for paddy fallow lands. The Chemistry division studied the effect of utilization of phosphatic manures, associated effect of legumes grown with cereals, and effect of trace elements on paddy and ragi. Studies are in progress to evaluate the use of liquid ammonia as a nitrogenous fertilizer to paddy crop.

A parasite on paddy grasshopper and a predator on sugarcane mealy bug were recorded and they are being studied in relation to their utility as a means of biological control of these pests.

Studies are also in progress to work out control measures of various crop diseases.

AGRICULTURE IN OTHER SOUTHERN STATES

Agricultural Colleges came into existence recently in the other states of Hyderabad, Andhra, Mysore and Travancore and the agricultural departments in these States are still in the infant and growing stages.

The Andhra Department of Agriculture was part of the Madras Department till the formation of the Andhra State in 1953. The work detailed under Madras, therefore, covers much of the work in the Andhra area also.

The Bapatla Agricultural College affiliated to the Andhra University came into existence in the year 1946. The set up in this College is almost the same as that at the Agricultural College, Coimbatore.

ANTHROPOLOGY AND ARCHAEOLOGY

ANTHROPOLOGY

In October 1945, the Department of Anthropology was opened at the University of Madras. Mr. M. D. Raghavan who was then the Head of the Department planned out the ways and submitted his proposals for the development of this Department to the University authorities. For the benefit of the post-graduate students only a two-year course in Anthropology was begun in July 1947 under Mr. L. A. Krishna Iyer. The successful completion in the respective examinations, Certificate and Diploma, entitled the candidates for their qualification in the subject. Students are taught during the two-year course Social and Cultural Anthropology, Physical Anthropology and Ethnology and Pre-historic Archaeology.

Dr. U. R. Ehrenfels was appointed as Head of the Department in July 1949. He has done much original researches in the study of both complex as well as simple societies in India. His theoretical and field work contributions in Indian Social and Cultural Anthropology have been mostly concerned with matriliny and tribal acculturation problems, thereby adding new view-points to the development of this discipline in South India, though he has also contributed the first tribal monograph of a food-gathering people in South India proper *i.e.,* the Kadar. For his researches in the comparative study of matrilineal civilization in India, he made five field-trips to the matrilineal Khasi, Garo and Lyngngam of Assam, since he joined this University, and altogether seventeen trips to Kerala, some of which were done in co-operation with his students.

In 1950, the Madras University started to offer research facilities for higher studies in Anthropology to students who are graduates in any field of study and who, in addition to their Degree possess also a Diploma in Anthropology of this University. On the proposals put forward by Dr. Ehrenfels, and on the recommendations of the Board of Studies in Anthropology, the Madras University has introduced Anthropology as Main and Ancillary subject in the B.A. and B.Sc. Degree Courses.

Sri M. S. Gopalakrishnan was appointed as Lecturer in the Department in 1955, and he, under the direction of the Head of the Department, Dr. U. R. Ehrenfels, and with his co-operation, conducts Certificate and Diploma Classes in Anthropology. As a research scholar in the Department between 1950-52, he made a special study of the Worship of the Mother-Goddess in two linguistically different areas, Madras and Malabar. The lecturer is now engaged in the study of the culture and practices of the Nambudiri Brahmins in Kerala.

The Department of Anthropology possesses a collection of about 300 books, and receives also Indian and foreign journals pertaining to the subject. There are a few skull-casts and models of fossil men, and a few stone implements, found in the Madras Presidency. These collections also include Khasi home industry material, photographs of Travancore (Kerala), Salem and Khasi, Garo, Lyngngam, Assam and Orissa Highlanders.

The Head of the Department is pursuing researches in various aspects of South Indian Cultural History, especially the changing position of women in India, and other Oriental and African societies and the North-South polarization phenomenon. Some of his significant works in this respect are:

i. *Mother-right in India,* (Oxford University Press), 1941.
ii. *The Double Sex Character of the Khasi Great Deity,* ("Madras University Journal"), 1950.
iii. *Ambivalent Attitudes to Women in Islamic Society,* ("Islamic Culture", Hydearbad-Dn.), 1951.
iv. *Kadar of Cochin,* (illustrated book), Anthropological Series, No. I, University of Madras, 1952.
v. *Khasi Kinship Terms, etc.,* ("Anthropos", Posieux, Switzerland), 1953.
vi. *Three Matrilineal Groups in Assam,* (American Anthropologist", Chicago, U.S.A.), 1955.
vii. *North-South Polarization,* ("Madras University Journal"), Centenary Special Number, 1956-1957.

The Lecturer has also contributed a number of articles on Anthropological themes to the "Tamil Encyclopaedia", Madras, and the "Madras University Journal".

In the Department of Anthropology, there are now 17 students studying for their Certifiate and Diploma Courses. There is a Government of India Senior Research Scholar working under the supervision of the Head of the Department of Anthropology, and one Madras University non-stipendiary research scholar.

In Madras there are now two organizations, (i) The Anthropological Society, and (ii) The Social Sciences Association, working for the development of Anthropology and other Social Sciences in South India. These associations hold periodic lectures by professors who have specialized in some branch of Anthropology. The School of Social Work, Madras, also popularizes Anthropology in South India.

The Osmania University, Hyderabad-Deccan, has got a Department of Sociology and Anthropology. It was in 1946 that the Department of Anthropology was started there, and Dr. Jafer Hassan is Professor and Head of the Department. Theoretical and Applied,—and Indian Sociology; Social,—Applied, and Indian Anthropology, Ethnology, Social Work, and Social Thought are taught at this University. In the B.A. and post-graduate classes these subjects are taught there, though actually no degree or diploma as such is given in Anthropology.

Prof. Haimendorf's works on the Chenchus and Hill Reddis, as Dr. Dube's on the Kamar of Madhya Pradesh have also thrown much light on the culture of pre-literate societies in South and Middle India.

The Mysore University has made provision for starting a separate department of Anthropology for post-graduate Diploma Course in the Maharaja's College, Mysore.

ARCHAEOLOGY

Archaeology as a subject of study and research has been receiving increasing attention in South India since the last quarter of the last century. In the early years of the last century individual scholars in South India were taking considerable interest in the study of some archaeological monuments and the preservation of the art treasures in South India. From about 1874 there was a proposal for organizing a regular archaeological survey in the south when the Secretary of State for India addressed a letter on the subject to the Provincial Government. However, nothing was done in the province except the appointment of Robert Sewell of the Provincial Civil Service for conducting certain explorations and making a list of the antiquarian remains in it. But organized attempts to achieve the above ends came to be made only from about 1881, when a Department of Archaeology was started for the South with a view to preserve the ancient monuments, and inquire among other things into the history of the Antiquities and Arts of South India. It was amalgamated with the western circle and placed under James Burgess. After various vicissitudes the department stabilized itself early in the present century. It is now a circle of the Archaeological Department of the Government of India with a Superintendent and an Assistant Superintendent at its head. At present Sri V. D. Krishnaswamy is the Superintendent and Ballab Saran, Assistant Superintendent. The main work of the Department is conservation of ancient monuments, exploration and excavation of ancient sites and remains, besides archaeological research. During the last 60 years or more the Department has undertaken excavations at important pre-historic and proto-historic sites. During the last 15 years organized work is being done by the Circle in the field of exploration and excavation. A survey was made of the Megalithic sites in the Chingleput and adjoining districts and more than 200 such sites have been brought to light in the region. Among the excavated sites prominent mention may be made to Adichanallur, a site of great significance in South Indian pre-history, Sanur, Amritamangalam, and Kunnatur, the last three are in the Chingleput district. Excavations have been made also at Sangamedu (South Arcot District) and Pallavamedu (Chingleput District). Besides, the Excavations Branch of the Archaeological Department has conducted excavations at Arikamedu near Pondicherry and Brahmagiri in the Chitaldroog District, Mysore State. Much of the time and energy of the Department is spent on the conservation of ancient monuments which constitute India's cultural heritage. The Ancient Monuments Preservation Act of 1904 provides "for the preservation of ancient monuments and for the protection and acquisition in certain cases of ancient monuments and of objects of archaeological, historical or artistic interest". The conservation of major monuments declared by Parliament by law to be of national importance was taken over by the Central Government in 1953 and a list of the more important ones was made and taken over by the Archaeological Department for such work.

The work of the Southern Circle of the Archaeological Department has been considerably supplemented by the work done in the former Indian States of Hyderabad, Mysore, Travancore, Cochin and Pudukkottai with regard to the exploration and excavation besides the preservation of monuments and archaeological research. Mysore was probably the first to start such a Department in 1900 and it has rendered valuable service to the monuments under its charge and undertaken excavations at important sites such as Brahmagiri and Chandravalli. The Hyderabad Archaeological Department was preserving the monuments at Ajanta and Ellora and undertook excavations at places like Maski and Kondapur. The Travancore and Cochin Archaeological Departments have preserved some of the works of Art in them. Though there was no Archaeological Department as such in the Pudukkottai State, the State maintained a number of archaeological monuments in it besides exploring and excavating many archaeological sites which have thrown much welcome light on some aspects of proto-historic culture in the region.

The Archaeological Survey of India has recently organized a 'Temple Survey Project' for South India for a study of the origin and evolution of South Indian architecture. It is under the charge of Sri K. R. Srinivasan, Superintendent for Archaeology.

A wing of the Archaeological Department is the Epigraphy Department, started in 1886. The Epigraphical Department has had a continuous and useful history, thanks to the sustained work and devoted labour of Epigraphists like Hultzsch, Venkayya, Krishna Sastri, Hirananda Sastri, N. P. Chakravarti, R. Krishnamacharlu, N. Lakshminarayana Rao, B. Ch. Chhabra, D. C. Sircar and others. Assisted by able and enthusiastic assistants the Department has been able to collect in South India so far more than 50,000 inscriptions, both copper plates and stone inscriptions belonging to different periods in South Indian history from the earliest times to almost the present day. As in the Archaeological Department the Epigraphical work in South India has been considerably supplemented by the Epigraphical work done in the former States of Mysore, Hyderabad, Travancore and Pudukkottai. The thousands of inscriptions collected by the Mysore Archaeological Department under L. Rice, Narasimhachar and others have been published in the Volumes of *Epigraphia Carnatica* and the *Mysore Archaeological Series.* The inscriptions collected in the Hyderabad State have been published in the *Hyderabad Archaeological Series.* The Travancore Archaeological Department has published in the *Travancore Archaeological Series* the inscriptions collected in the State. The Pudukkottai Durbar collected and published almost all the inscriptions found in the State in one volume. Summaries of the Tamil inscriptions that were collected in South India by Col. Colin Mackenzie in the early years of the last century have now been published by the Madras Government Oriental Manuscripts Library. The total number of inscriptions in South India so far collected comes to nearly 75,000.

Though South India is rich in Archaeological wealth and epigraphical material till recent years no provision was made in universities for the study of Archaeology and Epigraphy, as specialized subjects. In recent years, however, universities are taking interest in the subject and are providing facilities for study and research in them. Out of the eight universities in South India (Travancore, Annamalai, Madras, Venkateswara, Mysore, Karnataka, Osmania and Andhra) provision is made for the study of Archaeology in B.A. Honours and M.A. degree courses in the Universities of Mysore, Karnataka, Osmania and Andhra.

In Mysore the subject is studied by the History and Indology Honours students. For the History Honours students "Archaeology with special reference to India" is a minor subject and includes Epigraphy, Numismatics, Excavations, Architecture, Sculpture, etc. For the Indology Honours students also it is a minor subject. Indian Art and Architecture, however, make one separate paper and make a major subject. The Heads of the History and the Indology Departments respectively are Dr. S. Srikanta Sastri and Dr. M. Seshadri.

Provision has been made in the Karnataka University for the study of Epigraphy as part of the M.A. Course in Ancient Indian History and Culture.

In the Osmania University provision has been made for the study of Archaeology in the M.A. Course. Recently the Andhra University has introduced Archaeology and Epigraphy as two papers in the B.A. Honours Course in History. Dr. O. Ramachandrayya, M.A., Ph.D., and Sri Somasekhara Sarma are in charge of the course.

In the Madras University there has been a Department of Indian History and Archaeology since 1914. In view of the increasing recognition of the importance of Archaeology in South India, a separate section has been opened for Archaeology in the Department. Dr. T. V. Mahalingam, M.A., D.Litt., has been appointed Professor of Archaeology since July 1956.

Provision has been made for the appointment of a Lecturer, a photographer and a draftsman in the Archaeological section. It is proposed to start shortly a post-graduate Diploma course in Archaeology running to full two years. There will be 7 papers for it, viz.,

i. Principles and Methods of Archaeology.
ii. History and Civilization of the Middle East.
iii. History and Civilization of South-East Asia.
iv. Ancient Indian History and Culture.
v. Epigraphy and Numismatics.
vi. Art and Architecture, and
vii. Field training in Archaeology.

It is hoped that the course will enable students who undergo it to acquire a fairly good idea and experience in Archaeology and Epigraphy.

There are a few institutions devoted to Archaeological studies in South India. One of them is the Kannada Research Institute at Dharwar. It was started in 1939 and has now been taken over by the Karnataka University, Dharwar. The Institute contains a good research library relating to subjects like History and Archaeology, besides a number of research journals, Oriental manuscripts in Kannada and Sanskrit, impressions of about 800 stone inscriptions and 40 sets of copper plate grants ranging in date from about the first century A.D. to about the 17th century. There are also a palaeographic gallery consisting of original inscriptions from Karnataka, and Art gallery consisting of albums of photographs collected to provide a useful guide for the study of Iconography, Art and Architecture and line drawings and sketches of paintings and drawings and a museum containing a number of stone figures and model images, maps, charts, etc. The Institute provides facilities for post-graduate research in History, Ancient Indian Culture, Archaeology, Epigraphy, Architecture, Kannada Language, Literature, etc. Studentships and Fellowships have been instituted in it for encouraging students to have training in Research. Dr. B. A. Saletore is the Director of the Institute.

In Madras an Archaeological Society was organized in 1935 and has been in existence since then. The objects of the Society are the study and exposition of the history and evolution of Indian Culture and Civilization with special reference to South India, by holding periodical meetings for the presentation and discussion of papers by members and the publication of papers read before it in the *Transactions of the Archaeological Society of South India.* Two numbers have now been published and it is expected to be an annual feature hereafter.

ANTHROPOLOGY AND ARCHAEOLOGY IN SOUTH INDIAN MUSEUMS

In 1828 the Madras Literary Society and Auxiliary of the Asiatic Society of London began a campaign to establish a museum of economic geology. Lacking space and resources to arrange its collection of geological specimens it appealed to the Government of Madras in 1843 to find a public museum on the plea that there was need to develop the non-agricultural resources and also help the people to find new means for their economic improvement. The Madras Central Museum, interested to be associated with the University of Madras and in control of district museums where local industrial products and minerals would be collected and exhibited, was opened to the public in April 1851. Edward Balfour (1851-59), Assistant Surgeon of the Madras Army, who became the Surgeon-General later, organized it and in its early years was concerned mainly with a view towards exploiting the mineral and economic resources of the country.

Captain J. Mitchell (1859-72) who succeeded Balfour gave the museum a new orientation towards Archaeology and History. During his term he established contacts with the pioneer pre-historian of India, Robert Bruce Foote, which were to prove so fruitful later in obtaining for the museum and posterity one of the world's largest collections of pre-historic antiquities representative of the sub-continent of India that has come to be the standby of all later pre-historians as an index collection. Captain Mitchell also laid the foundation for the Numismatics section of the Museum by collecting coins and medals illustrative of the history of the Madras Army. It was again during his term that the arms collections of the Tanjore Armoury were transferred to the Museum from the arsenal of the Fort St. George.

Surgeon D. Bidie (1872-1884) will be remembered for bringing with the museum the large collection of pre-historic antiquities excavated from the stone circles, cairns and barrows of the Nilgiri Hills by Commissioner J. W. Breeks which were later catalogued by R. B. Foote (1902). It was also during his term that the nucleus of the large collection of Copper plate grants or charters of the historic period of South India was built up. At the present day there are over 400 of these charters and constitute an authentic record of South Indian history. More than anything else Surgeon Bidie's greatest achievement for the museum was in connection with the world-famous Amaravati marbles. The finest specimens of Buddhist sculpture appeared in the stupas of the Krishna valley in South India, especially at Amaravati and Nagarjunakonda. Fine marble panels depicting such scenes as the taming of the wild elephant, the division of the relics of the Buddha, the translation of Buddha's begging bowl to heaven and numerous other stories from the Jatakas are among the series.

Colonel Mackenzie discovered the Amaravati marbles in 1801. Governor Sir F. Adam of Madras wanted them to be preserved at Madras. During Surgeon Bidie's term these fine sculptures, the earliest of their kind in South Indian history found their way into the Museum and these give the visitor a clear visual impression of the glory of the classical age of stupa building.

Edgar Thurston (1885-1908) was the pioneer in the development of anthropological studies in South India. Ethnology was already introduced as a subject to illustrate the museum collections of ethnographic materials during the term of Surgeon Bidie. Thurston founded his Anthropometric Laboratory in the Museum and conducted the State Ethnographic survey of Madras which resulted in the publication of the Castes and Tribes of Southern India (1909). In this he was assisted by K. Rangachari, L. K. Ananthakrishna Iyer and others. Thurston was also responsible for the introduction of Anthropology as a post-graduate subject in the Madras University. It was during Thurston's time that R. B. Foote's famous collection of pre-historic antiquities was purchased for the Museum at a cost of Rs. 40,000. The reliquary caskets of crystal from Bhattiprolu and more sculptures from Amaravati were obtained for the museum during Thurston's time. Thurston will also be remembered for his work in Numismatics as he had catalogued several coin collections of the museum, especially of Roman, Portuguese, Mysore and Delhi Sultans.

During Dr. J. R. Henderson's term (1908-1919) the antiquities from the excavations at Adichanallur and Perumbair by the Archaeological Survey of India which found their way into the museum earlier were catalogued by A. Rea. These along with the earlier collections, Breeks and Foote, were catalogued by Foote and constitute the pioneer studies of the Stone Age and Megalithic cultures of Southern India. Henderson is also noted for his studies of the coins of Hyder Ali and Tipu Sultan.

The museum during Dr. F. H. Gravely's term (1920-1940) came to be the best equipped in India by virtue of its scope, research and publications. Working with a prominent band of colleagues in Archaeology and Anthropology Dr. Gravely established for the museum a very unique position in the field of research and popular education. It was during this period that studies of temple architecture, iconography, numismatics, prehistory, anthropology and linguistics received their largest share of attention. Among them are the works of F. H. Gravely and T. N. Ramachandran on Temple Architecture; T. N. Ramachandran on Metal Images, Sivaramamurti on Amaravati, T. G. Aravamudan on Roman and Venetian Coins, V. D. Krishnaswami on Pre-history of South India and the Punjab, A. Aiyappan on the Pre-history of Nellore District, Tinnevelly and the Perumal hills and the Anthropology of the Iravas, Nayadis and other tribes of the Wynad, and M. D. Raghavan on the dialects of South India. It was during Dr. Gravely's term that the Archaeological galleries exhibiting chronologically arranged series of Tamil, Telugu, and North Indian sculptures of the historical periods, the evolution of Indian scripts, and the Mohenjo-Daro Collections were added to the museum.

It was also during this period that the Chemical Conservation Laboratory, the first of its kind in India for the preservation and conservation of the world-famous bronze images was built up. The electrolytic preservation of bronze and other antiquities is a unique feature which is conserving for posterity the largest collection of over 1000 South Indian bronzes amongst which is the world famous Dancing Siva of Tiruvelangadu over the artistic excellence of which the French sculptor Rodin went into raptures.

During the last two decades under Dr. A. Aiyappan, the museum is maintaining international standards of scholarship and has built up extensive exchange relations with most foreign countries. The publications on temple architecture, metal images, coins of India and on musical instruments have gained great popularity. The anthropological publications have established themselves as books of reference among students and scholars. It was during this period that the museum celebrated its centenary after an unparalleled record of continuous service in the cause of popular education and scientific research. The Prime Minister of India inaugurated the celebrations on the 21st November, 1951 and declared open the National Art Gallery of Madras. The museum, since the inception of the University post-graduate Diploma and Certificate courses of study of Anthropology in 1946, is participating in the teaching and training of students. The museum participated in the enquiry conducted by the Government of Madras in the socio-economic conditions of the aboriginal tribes of the Province of Madras when Dr. Aiyappan published his report on the enquiry as Secretary of the Committee. In the field of archaeology the museum conducted tribal excavations at Arikamedu and Pallavaram subsequent to which the Department of Archaeology took over the former. The museum also sponsored the founding of the Fort Museum of the Department of Archaeology during this period to house the historical collections of arms and weapons and other associated exhibits characteristic of the British period in India. It was also during this period that the large index collections of pre-historic antiquities especially stone-age collections and collections of ethnographic materials representing both Indian and Foreign cultures were augmented, besides large stone age and megalithic collections from various excavations in India as well as representative collections of stone age tools from England, France, Denmark, Egypt, South Africa, Malaya, Indonesia, China and the United States of America. Ethnographic materials of the aborigines of Australia, New Guinea, Africa and North America are also being built up for both exhibition and teaching purposes. Popular guides to the museum galleries especially the archaeological galleries are a regular feature of the museum publication and among these the illustrations of Indian bronzes are very popular among the visiting public.

In its humble way the Madras Museum is helping its visitors to have a better appreciation of the history and culture of India, of the significant elements and factors of her achievements and the contribution of South India to the personality of India.

The Government Museum, Trivandrum was established in 1857. There is a curator in charge of this Museum. The Anthropological Section here contains life size models of Kani, Ullatan, Vishawan, Malaarayan, Mannan, Mala-Pandaram and Urali which represent the major tribes inhabiting the lower reaches of the Western Ghats. There is a general library attached to the Museum, and it contains some publications on Anthropology.

Hyderabad Museum, Hyderabad:

Established in 1931, it is housed in a picturesque building situated in the public gardens at Hyderabad. Among the exhibits in the museum are ancient images, reliefs, and architectural pieces recovered in the State. The Museum is under the charge of Khwaja M. Ahmad, M.A.

Mysore Government Museum, Bangalore:

The Museum was established in 1865 by the Government of Mysore and accommodated in its present building in the Cubbon Park in 1878. It contains exhibits of archaeological interest, images, architectural sculptures, pre-historic implements, pottery, copper plates, photographs dealing with the ancient monuments and history of Mysore and a large relief model of Seringapatam in 1800. The Museum is now under the charge of Sri Narayana Aiyangar.

Mysore Archaeological Department Museum, Mysore:

The Museum is attached to the Archaeological Department of the State and is in charge of Dr. M. Seshadri the Director of Archaeology, and Professor of Indology, Maharaja's College Mysore. The collections in the Museum comprise ancient inscriptions, coins, photographs of architectural monuments in the Mysore State and estampages of ancient inscriptions, copper plates, sculptures, coins and pre-historic and other antiquities such as beads and pottery from excavated sites in the State.

Pudukkottai Museum, Pudukkottai:

Opened in 1910, the museum is housed in two contiguous buildings at Tirugokarnam near the Pudukkottai town. Among the exhibits in it are pre-historic antiquities got in the course of excavations in the State, bronzes, sculptures and works of art besides a numismatic collection. The museum is now managed by the Government of Madras and is under the immediate charge of Sri S. Sundaram.

The Government (Napier) Museum, Trivandrum:

The museum was established in 1857 but was opened to the public in the present buildings in the public gardens at the place in 1880. Among the exhibits in the museum are archaeological exhibits like metal ware, bronze images, sculptures, pre-historic pottery, copper plates, coins, etc.

Sri Chitralayam (Gallery of Paintings), Trivandrum:

The Gallery which was opened in 1935 has a large collection of pictures representing the various eras of painting in India "along with some indication of the art in other parts of Asia that have been influenced by Indian culture".

The Archaeological Museum and Picture Gallery, Trichur:

It was founded in 1947. All the three are under the management of the Government of Kerala through Dr. R. Kesavan Nair, the Director of Archaeology in the State.

The Archaeological Department of the Government of India is running a few museums in South India.

(a) *Fort Museum, Madras*: It was founded in Fort St. George, Madras, in 1948 to house and display the relics and movable antiquities associated with the Fort and its history. The museum has at present separate sections for arms, oil paintings, coins, medals, porcelain, etc. The Curator of the museum is Sri K. Vijayaraghavan.

(b) *The Nagarjunakonda Museum*: This small but rich museum houses on the spot the antiquities recovered in the excavations of the stupas, monasteries, temples, etc., at Nagarjunakonda. Among the collections in the museum are inscriptions, coins, relics, pottery, statues and beautiful bas reliefs in the Amaravati style and depicting either the leading scenes of the life of the Buddha or illustrating Jataka stories and representations of stupas.

(c) *The Kondapur (Andhra Pradesh) Museum*: This is also a site museum and houses the antiquities recovered in the excavations at the site. The Curator of the museum is Sri Satyanarayana.

An important phase of the growth of museums in South India is the coming into existence of small but interesting museums in some large temples. Of them are the Rajaraja Museum in the Brihadisvara temple at Tanjore, and those in the temples of Ranganatha at Srirangam and Minakshi-Sundaresvara at Madurai, the first containing a remarkable collection of sculptures in stone and metal and the rest a collection of splendid ivories. The Art gallery at Tanjore managed by a committee at the place is another attractive museum in South India consisting largely of Chola sculptures.

BIOCHEMISTRY AND NUTRITION

BIOCHEMISTRY

Department of Biochemistry, Indian Institute of Science, Bangalore:

The department of Biochemistry, of the Indian Institute of Science is perhaps the earliest centre for biochemical research in South India. Started in 1911, this department has provided excellent facilities for training research workers in Biochemistry. Until about 1948, the emphasis has been more on the applied aspects of biochemical research such as the utilization and processing of indigenous raw materials by suitable biochemical methods, sewage purification, investigations on compost and activated sludge. Since 1948, there has been a shift in the emphasis on research on more fundamental aspects of biochemistry under Prof. K. V. Giri, such as circular paper chromatography and agar electrophoresis. The development of the circular paper chromatographic technique and the introduction of zone electrophoretic method incorporating an agar supporting medium have considerably added to the precision and simplicity of the separation and characterization of simple amino acids, proteins and peptides, carbohydrates, Kreb's cycle acids, vitamins and other metabolites formed by living cells. The agar electrophoretic technique has been very useful in following changes in the levels of protein constituents of the serum in health and disease. A clear cut separation of the various constituents achieved by this method has been successfully used to correlate their rise or fall in the serum with the onset of an infection or a functional disturbance in the human body.

Enzymes: Extensive research on several enzymes has also been carried out. The formation of oligosaccharides and polysaccharides by various enzymes like phosphorylases, transglucosidases, and transfructosidases present in plants (rice, green gram, etc.), moulds (*Penicillium chrysogenum, Aspergillus flavus*) and animals (rat liver). Some significant observations as tc the mechanism of their synthesis are on the type of primer for initiation and the effect of temperature on the nature of the polysaccharide synthesized. Enzymes synthesizing flavin nucleotides have been shown to occur in Indian pulses and more recently increasing attention is paid to the study of enzymes involved in the transport and metabolism of vitamin A and their intracellular distribution.

Antibiotics: Consequent to the sanction of a research scheme by the Council of Scientific and Industrial Research, followed by a grant from the Government of India, facilities were made available in 1948 for the study of plant and microbial antibiotics and for training research workers in this new line. Since 1948, in addition to various soil microorganisms about 400 Indian medicinal plants have been screened for the presence of antimicrobial agents in order to correlate the results with the practices of the indigenous systems of medicine. Three of the most potent antibacterial agents till now isolated from plant sources, viz, 'pterygospermin' from roots of *Moringa pterygosperma*, 'Guttiferin' and 'Morellin' from *Garcinia morella* were intensely studied. Morellin and guttiferin which could be readily prepared in large quantities were shown to be very useful in combating streptococcal and staphylococcal infection and in certain cases to offer decided advantages in matter of treatment and expense.

Another interesting item of research is the work on the nitrogen metabolism of *Penicillium chrysogenum* Q. 176 by the use of circular paper chromatographic technique of amino acids, which revealed the pattern of amino acid synthesis and their utilization by the mould, providing thereby a preliminary insight into the mode of formation of penicillin. In addition, several strains of moulds capable of forming penicillin at higher temperature have been taken up for study with a view to facilitate production of penicillin obviating the necessity for refrigerating equipment to control the temperature of the broths. A new line of work initiated this year with the help of the Indian Council of Medical Research relates to the screening of antibiotics, chemotherapeuticals and broths from soil actinomycetes for antivaccinia and anti-influenza activity.

Food and Nutrition: In the fields of foods and nutrition, this department has been one of the active centres of research on problems of nutritional deficiencies, specially relating to protein and vitamin deficiencies and of the effect of processing of food stuffs on their nutritional value. More recently, research work has been carried out on the effect of thermal treatment as commonly practised on the nutritional character of vegetable oils, and the nutritive value of groundnut protein when subjected to different processing like pressing, milling etc. The results obtained are of practical value in that they suggest the extent to which different food materials could be subjected to different types of processing before their nutritional qualities are significantly impaired. Further, in assessing nutritive value of various Indian foodstuffs, it was found that oils from the livers of a few varieties of fresh water fish, (*Wallagonia ottu, Ophicephalus striatus, Ophicephalus punctatus*) are exceptionally rich in Vitamin A_2, thus forming a convenient source for its isolation and for further biochemical studies. An interesting method now patented to combat Vitamin B_1 deficiency particularly in children, has been worked out by fortification of groundnut kernel with additional amounts of Vitamin B_1, which could be readily incorporated in sweetmeat and peppermints. The common practice of taking curds in every South Indian meal finds scientific justification in greater intestinal synthesis and absorption of vitamin B_1. Other interesting problems which have been studied relate to physico-chemical characteristics of proteins present in Indian pulses, photolysis of amino acid and non-enzymatic transaminations.

Since 1948 three hundred and forty four research papers have been published from this department and sixty eight research workers have received academic honours such as M.Sc. and Ph.D. degrees by carrying out post-graduate research work.

Biochemistry Department, University of Madras, Madras:

Next in importance as biochemical research institution in South India comes the department of Biochemistry of the University of Madras. This was started in 1933, and between the years 1933 and 1948, biochemical research with emphasis on studies of proteins, peptides and proteolytic enzymes was carried out by Prof. M. Damodaran and his colleagues. Thus the protein of the cashew nut (*Anacardium occidentale*) and the protein and other nitrogenous constituents of water melon seed (*Citrullus vulgaris*) were investigated as also the isolation of trypsin resistant casein phosphopeptone of constant composition. Research work in the field of enzymes related to ascorbic acid oxidase, glutamic acid dehydrogenase, aspartase and the milk clotting enzyme. Investigations were also carried out on the manufacture of sorbose, carbohydrate metabolism in microorganisms with special reference to oxalic acid and citric acid fermentation and the relation of dietary protein to blood regeneration. Since 1949, research work carried out by Prof. P. S. Sarma and his colleagues has been mainly in the field of water soluble vitamins and in the study of inter-relationship among vitamins and amino acids. Further, biochemical investigations employing radioactive isotopes of carbon, iodine, phosphorus and zinc have also been carried out and several significant results obtained. The following is a brief summary of some of the main findings during this period.

1. *Biosynthesis of ascorbic acid*: Using uniformly C^{14} labelled radioactive glucose, the direct conversion of glucose to ascorbic acid has been shown to take place in germinated seedlings. Further, the percentage conversion of radioactive glucose, fructose and sucrose to ascorbic acid was of the same order as that observed in albino rats. The influence of vitamins of the 'B' group on the biosynthesis of ascorbic acid has been investigated by employing the corresponding anti-vitamins and it has been shown that thiamine, pyridoxine and pantothenic acid play a significant role in the various enzymic steps involved in this conversion.

2. *Studies on tryptophane and nicotinic acid*: The factors which affect the conversion of tryptophane to nicotinic acid in various systems as in *Neurospora crassa,* germinating seeds, rice moth larvae (*Corcyra cephalonica St.*) and the albino rat have been studied particularly from the point of view of the influence of various vitamins of the B complex, and different carbohydrates and amino acids. The metabolism of nicotinic acid and nicotinamide studied in the rice moth larvae has shown that it differed in certain important aspects from that observed in higher animals. Further, a system bringing about deamination of nicotinamide has been investigated in the rice moth larvae and in *Neurospora crassa* and its locale in the cellular organization was found to be the soluble cytoplasmic material.

3. *Water soluble vitamins*: In the field of water soluble vitamins, investigations have been carried out on the separation and identification of all the members of the vitamin B complex by adopting simple chemical and fluorescence tests and by using the technique of ascending paper chromatography with a new solvent system consisting of n-butanol, methanol, benzene and water. Further, shark liver residue left over as waste material after extraction of liver oil was found to be a rich source of water soluble vitamins and liver extracts of appreciable nutritional potency have been prepared.

The role of 'B' vitamins, thiamine, biotin, p-amino benzoic acid, folic acid and pantothenic acid in amino acid metabolism in germinating green gram seeds (*Phaseolus radiatus*) has been investigated. It was found that during germination, there was a rapid fall in glutamic acid and a marked increase in the level of aspartic acid. Sulphanilamide produced an accumulation of histidine and arginine and a fall in the level of methionine and serine. Using glutamic acid and glucose, both uniformly labelled with C^{14}, the biosynthesis of asparagine has been studied in three species of legume seeds and using C^{14} labelled glucose, evidence has been obtained for the rapid synthesis of glutamic acid during germination.

4. *Nutritive value of reconstituted milk*: Reconstituted milk as prepared by the Government milk factory, Madras, was found to be inferior in nutritive value to fresh cow's milk or to toned milk as shown by growth experiments with albino rats. Estimation of different vitamins by chemical, spectrophotometric and microbiological methods showed that reconstituted milk had a lower vitamin value in regard to most of the vitamins investigated than either cow's milk or toned milk.

The growth promoting value of reconstituted milk for rats was not improved by supplements of different amino acids and vitamins but was improved markedly on supplementation with casein showing that the lower growth promoting value of reconstituted milk was presumably due to its low strepogenin content. Also evidence was obtained for the presence in skim milk powder stored at 37°C and 60°C of a substance toxic to *Lactobacillus bulgaricus* 09. This growth inhibitor was obtained in a concentrated form and its properties studied. The data obtained indicate that it is peptide in nature possessing antistrepogenin activity.

5. *Pyrophosphatase and phosphoprotein phosphatase*: French bean pyrophosphatase has been purified a hundred fold by fractional precipitation procedure and by adsorption on calcium phosphate gel. The purified pyrophosphatase did not show any activity towards sodium-B glycerophosphate, but it liberated orthophosphate phosphorus from sodium pyrophosphate, adenosine triphosphate and thiamine pyrophosphate.

A phosphoprotein phosphatase, specific for the dephosphorylation of phosphoproteins was detected in the tissues of higher animals and in oil seeds. The purification and characterization of this relatively little known enzyme has been studied in detail.

An enzymic method for the preparation of dephosphorised casein has been developed and amino acid analysis and tryptic and peptic digestion studies carried out on the dephosphorylated protein have shown the superiority of the enzymic method over the existing chemical methods. Further, an investigation of the biosynthesis of casein in the lactating mammary gland of rat has been carried out with radioactive phosphorus and evidence has been obtained to indicate the presence in this tissue of an active enzyme needed for the phosphorylation of proteins.

6. *Goitregenic agents in foods*: Investigations carried out on the goitregenic action of groundnut in albino rats have shown that the goitregenic factor is an anthocyanin arachidoside present in the red pigment of seed coats. This goitregenic action is overcome by additions of small amounts of iodine in the diet. Tracer studies with radioactive iodine (I^{131}) have shown that the action of this goitregenic factor consisted in competing with tyrosine for elemental iodine in the thyroid tissue. On similar lines, anthocyanins isolated from cashewnut red seed coat and from almond have been found to be goitregenic.

7. *Preservation of Neera*: Among the various substances tried for the preservation of Neera, the sweet palm juice tapped extensively all over India, it was found that the antimalarial substance "Paludrine" was quite effective in keeping this juice in an unfermented state for fifty four hours. The maximum concentration of 'Paludrine' needed was one in five thousand parts, though generally lower concentrations were found to be sufficient if weather conditions were favourable. Extensive field trials carried out at Udangudi in Madras state and at Marthandam in Kerala State have shown that Neera preserved with Paludrine is practically free from any alcoholic fermentation and that the palm gur prepared from such a preserved juice possessed better keeping qualities. A patent has been obtained for this process of Neera preservation by the Council of Scientific and Industrial Research, New Delhi.

Over one hundred and fifty research papers have been published from this department since 1933, in various Indian and foreign scientific periodicals including the Biochimia of the U.S.S.R., and many of the findings recorded therein, have found a permanent place in standard books in Biochemistry published in recent years. Further, during this period 1933-45, forty one post-graduate students were trained in biochemical research, of whom twelve obtained the M.Sc. degree and one the D.Sc. degree. During 1945-50, twenty were trained of whom nine got the M.Sc. degree and two, the Ph.D. degree. Since 1950, thirty students have been trained of whom 12 obtained M.Sc. degree and nine the Ph.D. degree. Also, since 1953, the M.Sc. degree course by examination in Biochemistry was started in this department by the University and until now ten have received the degree.

Department of Biochemistry, Madras Medical College, Madras:

The separation of serum protein fractions by paper electrophoresis and isolation and amino acid estimation of electrophoretically homogeneous albumin and globulin have been carried out by Professor Ninan Verghese. He has also studied the alterations in the amino acid composition in the globulin fractions with the variation in the albumin/globulin ratio. Among other investigations carried out in this department, mention may be made of the separation of urinary porphyrins by zone electrophoresis and their identification under ultra violet light and the study of protein fractions in cerebrospinal fluid in syphilis, meningitis and mental diseases. Methods have been developed for (i) chemical desalting of biological fluids especially urine to render them suitable for chromatography of amino acids and (ii) concentration of biological fluids with very low protein content so as to make them suitable for zone electrophoretic separation.

Other Institutions in South India:

In the Mysore University, a course leading to the M.Sc. degree in Biochemistry was instituted in 1953 and since then three students on an average are graduating every year in this subject. Research work on the action of amylases from different sources on starches of various kinds has also been undertaken in the chemistry department by Prof. M. Shadaksharaswamy. Research work and teaching in Biochemistry is also being carried out to a limited extent in the chemistry departments of the Andhra, Osmania and Kerala Universities, while in the Biochemistry divisions of the All India Institute of Mental Health, Bangalore, Regional Research Laboratory, Hyderabad, Central Food Technological Research Institute, Mysore and the Nutrition Research Laboratories, Coonoor, several students have been trained in post-graduate research work in Biochemistry for the research degrees of the various universities in South India.

NUTRITION

Nutrition Research Laboratories, Coonoor:

It is not an exaggeration to state that the nutritionists in India owe a debt of gratitude to the Nutrition Research Laboratories in Coonoor, South India where for the past four decades, starting with the pioneering work of its first Director, Sir Robert McCarrison, outstanding research work has been carried on, with an effort to solve nutritional problems of this vast sub-continent. Only by reading the publications of its second director Dr. W. R. Aykroyd and the comprehensive annual reports of its present director Dr. V. N. Patwardhan, one would appreciate the tremendous progress that has been made in the field of nutrition research due chiefly to the close collaboration between the chemists, physiologists, pathologists, clinicians and Public Health workers who work together in the Nutrition Research Laboratories as 'a close knit team'.

In this research station, excellent facilities for research in nutrition are being utilized for training young scientists in methods of research. A significant development in the past decade has been the recognition given by several Indian universities to the Nutrition Research Laboratories in Coonoor as a post-graduate research centre. This is a great help to the young workers who aspire to utilize the results of research work by them for the purposes of post-graduate degrees.

In order to make a thorough study of the aetiology of nutritional diseases, a nutrition clinic was established first in the Stanley hospital Madras and in 1947 this clinic was shifted to Coonoor in order to facilitate close collaboration between the research laboratory and the clinical investigations.

It will not be possible to elaborate on the tremendous amount of nutrition research that has been carried on in this place during the last ten years, but an attempt is made to report on some of the outstanding work to show progress in nutrition research.

1. *Nutritional Oedema in Adults*: From investigations, it has been found that Nutritional Oedema among adults, is a condition which is seen among the poorest section of our population and is the direct result of protein and calorie undernutrition. The diets of the patients investigated were found to be grossly deficient in calories and protein for several months prior to the onset

of Oedema. The Oedema was found to disappear completely in six to eight weeks on a dietary regime that supplied 55 g. of protein and 2300 calories per day together with a supplement of skimmed milk the quantity of which was gradually increased to 2½ pints.

Further investigations of Nutritional Oedema included determination of body composition at the time of admission and during rehabilitation, determination of basal metabolism and a study of pathogenesis of the disease. It has been reported that in advanced states of semistarvation the fat disappears almost completely, the lean tissues of the body are considerably reduced, the minerals undergo relatively slight change, while the water increases enormously. In the Oedema state it is gathered that both extracellular and intracellular fluid volume increases.

The basal metabolic rate (B.M.R.) estimated on Oedema cases was found to be below normal by 21%. After treatment, there was a rise in the B.M.R. even though it did not reach the normal level. It has been concluded from experimental observations that the reduction of B.M.R. at the height of Oedema is almost entirely due to a reduction of the active 'cell mass' and not to any reduction in the oxygen consumption per unit of metabolic time.

The occurrence of increased amounts of an anti-diuretic substance in the urine of Nutritional Oedema cases was reported and the suggested explanation was that the hepatic damage observed in such patients might interfere with the inactivation of the anti-diuretic hormone. This was put to test by studying the effect of starvation on the anti-diuretic potency of the liver in rats and from the results, it might be gathered that in starvation the liver is so damaged as to retard the inactivation of the anti-diuretic hormone of that organ.

2. *Nutritional Oedema Syndrome in Children (Kwashiorkor)*: The occurrence among poor children usually between the ages of 1 and 5 years of a disease characterized by Nutritional Oedema has presented a serious problem in child health in India. This disease is attended with high mortality and its large range crippling effects are apparently great. This syndrome in children has attracted world wide attention and the salient clinical features are marked failure of growth, swelling of the body, diarrhoea and discolouration and spareness of scalp hair. The child may also

show skin changes and enlarged liver. It is extremely apathetic to its environment.

A thorough inquiry into the incidence of the Nutritional Oedema syndrome in children included (1) collection of precise information regarding the aetiological factors including dietary background of these cases, (2) studies on the use of skimmed milk or vegetable protein substitutes in the treatment of the disease, since milk is beyond the reach of the poor people in India (3) observations of pathological and biochemical changes in liver and other tissues (4) pathogenesis of the disease and (5) experiments on monkeys and rats.

Clinical investigations of *Kwashiorkor* during the last three years included (1) detection of steatorrhoea in a large number of cases investigated, (2) body composition studies on animals to evaluate vegetable protein diets in its treatment (3) an inquiry into the role of maternal malnutrition related to this syndrome (4) a study of haematological changes and (5) Observations of some aspects of hair changes in this condition.

Further investigations on the treatment of *Kwashiorkor* consisted in finding out the optimal level of protein intake required for successful treatment. It is reported that cases in Coonoor had been treated successfully with 60 g. of protein intake daily even though Dean has suggested a higher level upto 100 g. per day for treatment.

It is reported that (1) comparison of the response to treatment with 60 g. and 100 g. of protein daily in two groups of cases of no significant difference with regard to serum albumin and clinical improvement, (2) cases of *Kwashiorkor* showed sub-normal levels of serum sodium and calcium on admission. After high protein diet treatment, the values rose to normal levels.

A résumé of some of the other investigations is given below:

3. *The metabolism of animal and vegetable proteins by Indian adults*: It was observed repeatedly that the urinary nitrogen excretion on the predominantly vegetarian diet was definitely lower than when animal protein formed 50% or more of the total proteins present in the diet. It was also found that urea accounts for the excess nitrogen observed on the animal protein diets. It was also shown that vitamin B_{12}, liver extract or other factors possibly associated with animal protein do not have any influence

on the urinary nitrogen excretion observed in vegetable protein diets. The minimum protein requirement in adults has also been studied and compared with similar studies in the west.

4. *Nutritive value of Duck Egg White Protein*:• A comparative study of the nutritive value of Duck's egg white protein and Hen's egg white protein showed that a powerful comparatively heat resistant antitryptic factor (an ovomucoid) occurred in the Duck egg white and interfered with the digestion of protein in the intestine by inhibiting the liberation of some essential amino acids.

5. *Skin Malnutrition*: It appears that a majority of skin conditions due to malnutrition arise out of deficiencies of one or more members of the vitamin B_2 complex. Some skin manifestations are associated with calorie and protein undernutrition. It is also becoming increasingly clear that dietary fat is an important factor in maintaining the health of the skin.

6. *Studies on Edible Fats and Oils*: The argument against Vanaspathi (Hydrogenated vegetable oil) that the traces of nickel present in it were deleterious to health was put to test by the animal feeding experiments. The feeding of nickel containing diets to rats and monkeys failed to produce any toxic effects even after feeding nickel continuously to rats for over a year and to monkeys for over six months at levels equivalent to 250 to 1,000 tins, the amount likely to be ingested by man if Vanaspati formed the only article in his diet.

Women's Christian College, Madras:

In the department of Physiology & Nutrition, Women's Christian College, Nutrition research was begun in 1942 by Prof. E. D. Mason and her graduate research students who had used the results of their investigations in their theses for the degree of Master of Science in Nutrition.

Since 1942 the department has carried on experiments with the 'poor' rice diet of South India, using young albino rats as test animals. Early experiments were designed to test the effect of common cheaply available foods as supplements to the rice diet. The constituents of milk were also tested as supplements and these experiments led to the interesting observation that butter fat retarded the growth of rats on the 'poor' rice diet to a marked degree. Experiments were also conducted to test single factors such as vitamins known to be deficient in the rice diet and the findings formed the basis of a thesis "The Supplementary effect of calcium and vitamins with the 'poor' rice diet with reference to growth, the osseous system and the occurrence of paralysis in young albino rats". The earlier observation that fat had a deleterious effect on the growth of weanling rats fed with the rice diet was pursued further and these findings were presented in a thesis, "Studies on the nutritive value of butter fat and oils as a supplement to the 'poor' rice diet of South India with special reference to gingelly (seasame) oil".

Human nutrition studies were also carried on in this department. A survey was made of the diets of children in twenty boarding schools in South India. In the majority of cases, their diets resembled the 'poor' rice diet of South India which consists of nearly 90% rice. An attempt was made to introduce into these schools a diet costing no more than that already supplied to the children but of definitely superior nutritive value (as tested on weanling rats). This 'experimental school diet' gave a marked improvement in the health of the school children. The findings of this investigation were presented in a thesis, "Feeding of Children in South India. An investigation of various aspects of the problem". In this study, data were also collected to establish height-weight standards for South Indian school children.

Nitrogen balance experiments were conducted on South Indian women subsisting on the college hostel diet, to study the effect of variation of calorie intake and the effect of the quality of dietary protein on nitrogen balance, particularly on the elimination of nitrogen in the urine in the basal non-vegetarian diet as compared with the experimental vegetarian diet.

In continuation of the work of Dr. E. D. Mason of this department who found that the basal metabolic rate of South Indian women was lower than that of western women, two groups of school children have been studied and the results were presented in a thesis, "A comparative study of the basal metabolic rate of South Indian and Anglo-Indian girls from 9 to 16 years of age and the factors influencing these rates".

Research work on food analysis consisted of analysis of South Indian food preparations and analyses of some edible green leaves in South India. These had not been analysed before.

The effect of some South Indian methods of cooking on the nutritive value of vegetables have been studied. The work relating to ascorbic acid was presented in a thesis "The study of the effects of some South Indian methods of cooking on the ascorbic acid and calorie content of Indian vegetables". Similar work with regard to carotene was also presented in a thesis "Studies on the effect of cooking, storage and dehydration on the carotene content of South Indian vegetables".

Further investigations on nitrogen balance and on the 'poor' rice diet are in progress, carried on jointly by Dr. R. Arulanantham, Research Associate, and Miss. F. Theophilus, Professor of Physiology & Nutrition. During the past decade six graduate students have submitted thesis to the University of Madras for the M.Sc. degree in nutrition and some papers have been published in scientific journals.

Christian Medical College, Vellore, South India:

In the Department of Biochemistry, Christian Medical College, Vellore, researches have been directed particularly towards nutritional problems such as the studies in Indian fish liver oils and prawns. With a view to finding out whether there exists any relationship between the colour of the liver oil, its different physical and chemical constants and vitamin 'A' content, six varieties of liver oils were studied. The fish yielded a large amount of liver oil with high vitamin content. The oil was extracted and analysed month by month and the different physical and chemical constants of the oil along with the vitamin A content were investigated. It was found that (1) there was no relation between the colour and its different constants; (2) an increase in vitamin A content was followed by (a) increase in saponification value, (b) no marked change in specific gravity and acid values and (c) decrease in iodine value.

The same varieties of oils were analysed for the vitamin A content biologically. Great variation in vitamin A content was observed when compared with the values obtained by colorimetric methods. Though it was not possible to draw any definite relationship between the colour of the oil and its vitamin potency, it was noticed to some extent that a decrease in the percentage of vitamin A was accompanied by an increase in red colour of the oil.

Another series of studies in the chemistry of prawns and fish liver oils (Vitamin D) were undertaken. Five different types of phosphorus compounds were detected in prawn muscle and estimated quantitatively. Prawns constitute a good source of protein of quality, and the evaluation of protein by two methods has been undertaken. The distribution of organ protein newly formed in growth over a period of 18 days on different levels of protein intake, is taken as a measure of the protein value. It is found from the results that this method cannot be used satisfactorily for the evaluation of prawn protein. But on the other hand, a satisfactory method of protein evaluation was developed by studying the effect of prawn proteins at 5, 10, 12½ and 15% levels of intake on the growth of skeleton, specially the long bones. In this study an optimum of 12.5% protein intake was established and with an increase in the protein intake there appeared gradual increase in the skeletal growth as well as ash content.

The best criterion for the determination of vitamin D is the ash content of the bone and has been used in the study of fish liver oils for the determination of vitamin D. This measures the calcification of bone or bones which may be considered representative of the whole skeleton. It was found that the vitamin D content of the fish liver oils was almost negligible in comparison to their vitamin A content.

Central Food Technological Institute, Mysore :

Research in Nutrition has been carried on in the Central Food Technological Institute and the results have been published in the Bulletin of this Institute as well as in Scientific Journals.

NUTRITION EDUCATION

Nutrition Research Laboratories, Coonoor, has been an active centre for spreading Nutrition Education and doing field work on nutritional problems. Short courses in the theory and practice of nutrition are held annually in this institution for about 3½ months from the middle of March to the end of June. The students work in the laboratory and the clinic where cases of nutritional diseases are demonstrated. Methods of investigation and treatment are taught in theory and practice. Instruction on the Public Health aspects of nutrition is also given through such practical work as diet surveys in families and in school children.

Nutrition is a branch of study suitable for women who will be home makers. Hence the University of Madras has made provision for teaching this subject as a part of Household Arts at the Intermediate level (now Pre-University level) and as a part of Home Science in the B.Sc. degree level. In July 1942, the two Women's Colleges, Queen Mary's College and Women's Christian College, both at Madras offered B.Sc., Home Science course jointly to women students. In the Women's Christian College over 110 students have done Nutrition in their degree course during the last 15 years. In Queen Mary's College, Madras, only 16 students were admitted each year for the B.Sc. degree course since 1950 and this number was increased to 24 in 1955 and to 32 students in 1957. Over 160 students have passed through the Queen Mary's College with graduate qualification in Home Science.

Maharani's College for Women, Bangalore, affiliated to the Mysore University also offers Home Science at the degree level. This course also includes Food and Nutrition as a part of the syllabus and has been in existence since 1953. Over 116 students have acquired their Bachelor's degree from the Maharani's College.

S.I.E.T. College for Women (Madras) is one of the new colleges that has started recently the three year degree course in Home Science.

Recently, the M.Sc. course in Institution Management and Dietetics has been started at Women's Christian College. 4 students have been admitted in July 1956 and a second set of 4 in July 1957. The M.Sc. degree syllabus emphasizes the application of the theory of nutrition in hospital diets and institutional food service, through laboratory exercises, internships and work experience in several food service institutions.

BOTANY

1. *Department of Botany, Presidency College, Madras*:

The Presidency College, Madras, which celebrated its Centenary in 1940 is an institution affiliated to this University. The Botany Department of the College imparts teaching both at the graduate and post-graduate levels and for many years past has been in the charge of staff engaged in research also.

Staff: One Chief Professor, an Additional Professor, four Assistant Professors and four Demonstrators.

Teaching and Research Facilities: The institution is essentially a teaching one, training students at the B.Sc. and B.Sc. Hons. levels. The Department is well equipped for research also and a number of candidates have carried on research leading to the M.Sc. degree.

Résumé of research:

The exploratory investigations of the late Professor P. F. Fyson on systematic botany and related subjects concerning the Madras State have resulted in the production of an authoritative, illustrated regional flora of the South Indian Hill-tops, in addition to enabling the author (Fyson) to discover several species of plants new to science. Numerous research papers with particular reference to taxonomy were published during his tenure, amongst which mention must be made of the "Revision of *Eriocaulon*" in India. Prof. Fyson's interest and delight in popularising botany is exemplified by his beautifully illustrated and accurately annotated series of publications under the title, "Madras Flowers". It may also be mentioned here that the Indian Botanical Society, and its official organ, *The Journal of the Indian Botanical Society,* had their birth in this Department when Prof. Fyson was the Head of the Department, and that these institutions were nurtured for a considerable time by him and his successors, notably Prof. M. O. P. Iyengar. The research tradition was carried further by Prof. M. O. P. Iyengar in Algology, and later by Prof. T. Ekambaram in Physiology and General Morphology of plants. During succeeding years, these branches continued to receive impetus at the hands of able staff. New disciplines like embryology, anatomy, and general comparative morphology were initiated in 1953 with the appointment of Prof. B. G. L. Swamy as Chief Professor.

For the past ten years, the following lines of investigations have received attention:

1. Algology: Life-histories, structure and development, ecology.

2. Embryology: Angiosperms and gymnosperms.

3. Anatomy: General anatomy, histology and wood anatomy. The Department has microslides of nearly 6,000 species of woods as a reference collection, the sampling being fairly representative so as to facilitate survey types of investigations. New species are continuously being added on. One of the major investigations of this type on hand is the origin, distribution, and diversification of Septate Fibres in the dicotyledons. Still another project concerns the distribution-patterns of the inter-xylary parenchyma with individual families and amongst dicotyledons as a whole.

In general anatomy, vegetative structures like node, leaves, seedlings, flower, etc., are being studied, with particular reference to the Ranales, and also with reference to a few other families like the Alangiaceae, Olacaceae, Opiliaceae, Saxifragaceae, Santalales, etc.

4. Studies pertaining to the range of structural variability in arborescent monocotyledons like the Palmaceae, Graminaceae, Liliaceae, etc., are being studied. Important data have been collected in regard to the *modus operandi* of the increase in girth of the stem, and the variability of anatomical structure during the process. The results are scheduled to be published in a series of contributions. Studies on the morphogenetic implications in the ontogeny of the palm leaves are also in progress

5. Studies pertaining to the anatomical variability in the tissues of the secondary xylem formed during one growth-season have been initiated. Considerable data have been collected with reference to all types of derivatives of the fusiform initials of the cambium. Final analysis and conclusions are being worked out.

6. A beginning has been made in studying the morphogenetic implications of the patterns of foliar vascularization in some of the woody Ranalian families, and also in studying the pathological histology of tissues infected with insects, fungi, viruses, etc.

7. The Department has a comprehensive collection of the vesselless dicotyledons, living and fossil. These curious relics are being intensively studied from a broad morphological and comparative front.

8. The "Herbarium Collegii Presidentiae Madrasensis", the nucleus of which was started by Prof. Fyson, has been steadily growing. A new (occasional) series of publications, "Commentaria Herbarii" are being published.

Contributions on the above mentioned research work have been and are being published in various scientific periodicals.

2. *Department of Botany, University of Madras*:

The first Honorary Director, Professor T. Ekambaram initiated some amount of work in Botany in 1930 and during the short period of his tenure of office, three theses and some publications appeared. It was only in 1933 that Professor M. O. P. Iyengar took over as the first permanent Director and established a school of research in the field of Algology. In 1944 there was a re-orientation of the work from Algology to Mycology and Plant Pathology in the Department, with the appointment of Professor T. S. Sadasivan as Director, in succession to Prof. Iyengar.

Staff: One Director (Professor), one Reader, one Senior Lecturer and one Research Assistant.

Teaching and research facilities: This Department has been a post-graduate research institution all along and data relating to the award of research degrees and research output since 1930 are as follows: M.Sc.: 28; Ph.D.: 21; D.Sc.: 1. The Department is excellently equipped for work on various aspects of Plant Pathology, Physiology of micro-organisms, Taxonomy of Fungi and Algology and there are about 17 workers carrying on research. In addition, a post-B.Sc. Hons. one-year M.Sc. degree course in Plant Pathology was instituted in 1951 and the output per year is 2-3. The staff of the Department also partakes in the Inter-Collegiate Lecture Scheme of this University for post-graduate and Honours students.

Résumé of research: The work carried out in this Department is briefly summarized below under the heads, Algology, Plant Pathology and Physiology of Fungi, and Systematic Mycology and Taxonomy of Fungi.

1. *Algology*: The work initiated by Prof. M. O. P. Iyengar was broad based and covered limnological observations of fresh, estuarine and marine algal forms, systematics, life-histories, morphology and cytology. Much of this was pioneering work in so far as this country was concerned.

In the field of systematics the major work has been on living and fossil diatoms, desmids and blue-green algae. Several new genera belonging to various groups of algae were described: *Cladospongia* Iyengar & Ramanathan, *Characiosiphon* Iyengar, *Pseudovalonia* Iyengar, *Triplastrum* Iyengar & Ramanathan, *Hormidiella* Iyengar & Kanthamma, *Heterothricopsis* Iyengar & Kanthamma, *Gloeotilopsis* Iyengar & Philipose, *Chrysodictyon* Ramanathan, *Mastigocladopsis* Iyengar & Desikachary, *Camptylonemopsis* Desikachary, *Iyengariella* Desikachary and *Cylindrocapsopsis* Iyengar. Many new species and forms belonging to different groups were also described.

Life-history studies were carried out on a number of forms, notably in *Eudorina elegans, Pseudovalonia forbesii, Caulerpa, Characiosiphon rivularis, Anadyomene stellata, Microdictyon tenuius, Cyclotella meneghениana, Characium terrestris, Enteromorpha, Carteria, Bacteriastrum, Navicula halophila,* etc. Life-history studies have also been carried out on several of the new genera already mentioned.

Another aspect on which much attention has been focussed is the developmental morphology and cytology of many tropical forms such as *Melobesia farinosa, Grateloupia lithophila, Eudorina indica, Spirogyra, Polysiphonia platycarpa, Enteromorpha compressa* var. *lingulata, Micrasterias denticulata* var. *notata,* various species of diatoms, and *Chara zeylanica.*

The outcome of all these carefully planned and critical investigations has been one of enriching our knowledge of algae. Indeed, much of the work on the green algae has been summarized by Prof. Iyengar in the *Manual of Phycology,* edited by Prof. G. M. Smith.

More recently, algal work is being continued. The work is mainly on comparative morphology and cytology of the Rhodophyceae, especially the Nemalionales, Cryptonemiales and Ceramiales, developmental morphology of the Charales, and the control of algal growth in waters. Prof. Iyengar is actively continuing his work on Algae, especially on the Chlorophyceae, under the auspices of the University of Madras and the Council of Scientific and Industrial Research, in this Department.

An Algal herbarium and collection of Algae consisting of the bulk of Prof. M. O. P. Iyengar's collections from different parts of India are housed in the University Botany Department. This valuable collection includes authentic specimens and types of Boergesen's South Indian Marine Algae.

2. *Plant Pathology and Physiology of Fungi*: Broadly speaking, the following investigations have been undertaken since 1944: soil-borne diseases of plants (including micro-ecology of soil fungi and other micro-organisms), physiology of fungi and physiology of host-parasite relationships, particularly Fusariose wilts in plants, techniques in bioassy and chromatography, spectrochemical studies of uptake of ions by plants, vivotoxins and fungal enzymes, respiration and electrophoretic studies in plant tissues.

The work on soil conditions and root diseases, particularly those of cotton and pigeon pea, has been one of detailed studies of survival of fungal pathogens in soils on the face of amendments and as affected by soil microfloras. The role of trace elements in the control of plant wilts, for which considerable evidence has accumulated, has been reviewed in detail.

The symptomatology of Fusariose wilt of cotton has been studied in detail particularly in relation to internal changes such as ascorbic acid, chlorophyll, reducing sugar and protein and non-protein nitrogen contents. Histological changes have also been studied.

Much evidence has been presented by workers in this Department in the elucidation of the mechanism of Fusariose wilts of plants. There is overwhelming evidence to show that the disease syndrome is the result of toxaemia rather than one solely of mechanical vessel plugging induced by pectic enzymes or polysaccharides, etc. The demonstration of the production of fusaric acid *in vivo* in cotton plants infected by the fungus was made by using a chromatographic technique, chelating the fusaric acid from internal tissues of the host with copper which gave specific R_f values. This has been confirmed further by using a bioassay *cum* chromatographic technique. It has also been shown that *Fusarium vasinfectum* produces antibiotics in the unsterilized soil.

Study of enzyme systems both of the cotton plant and *Fusarium vasinfectum* has yielded fruitous results. For instance, sizeable quantities of cystine along with other major amino acids like asparagine and glutamine were present in the resistant varieties of cotton examined but were absent in a susceptible cotton variety tested and it is suggestive of this cystine of the resistant variety of cotton chelating with Fe''' available in the host and rendering this quantum of iron unavailable for chelation with the toxin which appears to be a pre-requisite for toxigenic wilting of cotton. Work on pectin methyl esterase and pectin galacturonase activity of Fusaria indicated that high root pectin content of cotton plants seems to be correlated with susceptibility and low levels with resistance and the main seat of pectin synthesis and storage in the susceptible variety is the root while it is the shoots and leaves that accumulate higher pectic reserves in the resistant cotton varieties studied.

Recently, spectrochemical studies have been initiated in studying uptake of metabolites by wilted plants and the consequent derangement thereof in the mobility of ions. It has been shown, using the standard Lundegårdh (spark-in-flame) technique that cotton plants infected by *Fusarium vasinfectum* showed an increased uptake of magnesium, calcium, iron and manganese and decreased accumulation of potassium over the healthy controls. More recent work presents strong evidence of appearance of ionized calcium during pathogenesis. Although the resistant plant also shows ionized calcium lines nearly as strong as the susceptible plant under toxaemia, the healthy susceptible plant shows very weak ionized Ca lines. Therefore, Ca ionization is essentially ascribable to the possible dissociation of the fusaric acid molecule *in vivo* and the consequent changes it could have brought about in respiration and in the ionization of the neutral Ca. This evidence is suggestive of a poisoning effect of the tissues resulting in major ionic derangement *in vivo.*

Work on root exudates indicates differences in the amino acid exudates from rice plants resistant and susceptible to the foot rot fungus, *Fusarium moniliforme.*

In the field of physiology of fungi, growth factor studies have been carried out with many genera of tropical fungi such as *Pelli-*

cularia koleroga, Piricularia spp., *Sclerotium oryzae, Corticium microsclerotia,* and *Cercospora personata.* The physiology of Fusaria has been investigated in detail with special reference to aeration, carbon, nitrogen, trace element and pH relationships. The essentiality of certain heavy metals to growth and sporulation of Fusaria has been demonstrated by bioassy techniques (using *Aspergillus niger,* 'M' and 'M.U.B.L. 1' strains). Work on different strains of *A. niger* has shown different degrees of sensitivity in the detection of heavy metals. The Madras strain ('M.U.B.L. 1') was found to be less sensitive to traces of manganese and more sensitive to copper, and perhaps molybdenum also, than the standard 'M' strain.

3. *Systematic Mycology and Taxonomy of Fungi*: In the field of systematic mycology, detailed studies were made on the fungus floras of soils and the rhizosphere of crop plants. Soil Fusaria and Fusaria infecting crop plants were intensively investigated and systematic accounts have been published. The question of the "wild type" in the genus *Fusarium* has been considered in the light of work on a large number of fresh isolates of different species obtained from soils as well as from crop plants; it was concluded that species of *Fusarium* occur in nature in a multiplicity of forms and not as a single "wild type". More recently, problems relating to classification of Fusaria were also critically reviewed and discussed.

Apart from studies on soil fungi, considerable work has also been carried out on other saprophytic and parasitic fungi which include many new records for India and many new taxa. The Fungi Imperfecti have received much attention and 26 new genera have been described, of which 18 are hyphomycetes and 8 are coelomycetes; seventeen of the hyphomycete genera were established by Subramanian, and the coelomycete genera, jointly by Subramanian & Ramakrishnan. The 17 new hyphomycete genera are: *Beltraniella, Lacellinopsis, Koorchaloma, Lomaantha, Lomachashaka, Paathramaya, Prathoda, Tharoopama, Phaeotrichoconis, Prathigada, Dwayamala, Kutilakesa, Nalanthamala, Bahusandhika, Vakrabeeja, Dwayaloma* and *Sadasivania.* One new hyphomycete genus, *Starkeyomyces* was described by Agnihothrudu. The 8 new coelomycete genera are: *Plagionema* (currently a synonym of *Ciliochorella*), *Rostrospora, Petrakomyces, Anthasthoopa, Alpakesa, Shanoria, Samukuta* and *Sakireeta.* In the Ascomycetes, one new genus, *Sapucchaka,* was described by Ramakrishnan.

Taxonomic studies on hyphomycetes and on some genera of the Coelomycetes such as *Neottiospora, Amphichaeta* and *Ciliochorella* have also been in progress. Systematic accounts of Indian species of *Curvularia* and *Periconia,* and South Indian Myxomycetes have been published.

A mycological Herbarium was started in 1951 and many of the observations and records made from periodical collections of fungi largely by Drs. C. V. Subramanian and K. Ramakrishnan have yet to be published.

Two lengthy and important compilations on Indian fungi were also brought out during the period. One is a list of fungi recorded in India during 1938-1952, intended as a successor to Mundkur's *Fungi of India—Supplement I* published in 1938; the second is a similar list covering the period 1952-1956. A list of Indian soil fungi, including the larger fungi, was also published in 1952. These lists are largely intended as an aid to workers in systematic mycology and taxonomy of fungi in this country and, indeed, contain a very complete bibliography of Indian systematic mycology during the period 1938-56.

Well over 200 scientific papers have been published from this Department so far.

Special Schemes of Research: The following special schemes of research are in progress: (i) an I.C.M.R. scheme for research on lathyrism; and (ii) a Tata scheme of research on control of algal growth in works.

Finance: Besides provision for annual expenditure on various items in the Budget, the Department has received generous grants in the past from the Ministry of Education, Government of India, and the University Grants Commission. Such grants have been spent in equipping the laboratory for precise scientific work, especially spectrochemical analyses, respiration studies, etc.

There are 6 research studentships offered by this University, in addition to 5 Government of India research scholarships. There are also one National Research Fellow, two I.C.I. Research Fellows of the National Institute of Sciences of India, one cultural scholar of the Government of India from Ceylon, and one Research Fellow from the Mysore University, working in the Department.

3. *Department of Botany, University of Mysore, Central College, Bangalore* :

In the year 1919, the late Prof. M. A. Sampathkumaran, the first Professor of Botany in the University of Mysore, established a school of research in plant cytology, embryology and taxonomy in the Central College, Bangalore. This school collected within its fold a band of enthusiastic workers and has developed from year to year since then.

After the retirement of Prof. Sampathkumaran in 1942, Dr. L. Narayana Rao took over charge as Professor and occupied the Chair up to 1954. When he retired Dr. C. V. Krishna Iyengar succeeded him for a short period of one year. In 1955 Dr. K. N. Narayan, the present Professor, was appointed Professor and Head of the Department of Botany, University of Mysore.

Staff : One Professor, two Assistant Professors and 11 Lecturers.

Teaching and research facilities : Teaching is imparted both at the graduate and post-graduate levels, leading to the M.Sc. The Department is equipped for research in Cytogenetics, Plant Morphology, Plant Physiology, Taxonomy, etc. The research output has been : D.Sc. : 4; Ph.D. : 4.

Résumé of research : Since the very beginning the Department has been actively contributing to the development of Botany in the country. Over 500 original papers in plant taxonomy, embryology, cytology, mycology and physiology have been published in several leading Botanical journals of the world.

Among the earlier workers in plant morphology mention may be made of Prof. L. N. Rao, Dr. S. B. Kausik and Dr. B. G. L. Swamy who have made significant contributions in embryology. Their work not only gave a great impetus to the development of embryology but also lead to the establishment of a good school of plant embryology. The embryology of the following has received particular attention : Commelinaceae, *Vallisneria* and *Blyxa, Limnophyton,* Malpighiaceae and *Artocarpus,* Leguminosae, Apocynaceae, Melastomaceae, Stylidiaceae, Lobeliaceae, Gesneriaceae, Euphorbiaceae, Scrophulariaceae, Orchidaceae, Araliaceae, Podostemaceae, Polygalaceae, Rhamnaceae, Combretaceae, Bignoniaceae, Santalaceae, Liliaceae, Loranthaceae, Palmae, etc.

In the field of cytology, Dr. K. V. Srinath made important contributions and this work is being continued. Dr. K. N. Narayan has been working on the cytogenetics of grasses and work on *Pennisetum* and *Saccharum* is in progress.

Prof. L. N. Rao initiated work on plant physiology in the Department in 1928. Later, Dr. C. V. Krishna Iyengar took up work in plant physiology and published a number of papers on the movements of leaves and the relationship of water contents of the plant and reversible changes in the tissues of plants.

In 1938 Dr. M. J. Thirumalachar started work on mycology, floristics and anatomy. He described about eight genera and three hundred new species of fungi. This work is being continued and work on the genera *Albugo, Sclerospora* and *Cercospora* has been caried out.

4. *Department of Botany, Osmania University*:

A Department of Biology was started in the Osmania University in 1923 when instruction was given to the Intermediate classes only. In 1929 Botany and Zoology were introduced as optional subjects at the B.A. level which was later changed to B.Sc. The Department of Biology was split up into its two components, i.e., Botany and Zoology, about the year 1935 when the M.Sc. course in Botany was started. The first research paper on the Flora of Hyderabad was published in 1933. Research in anatomy was taken up in 1939 and on pollen morphology in 1942. In 1950 the mycological and the hydrobiological research laboratories were started and students for research leading to the Ph.D. degree were admitted. By 1951, good research facilities for work on anatomy and taxonomy became available.

Prof. M. Sayeed-ud-Din is the present Professor and Head of the Department.

Staff: One Professor, three Readers and ten Lecturers.

Teaching and research facilities: Teaching is imparted both at the graduate and post-graduate levels, leading to the M.Sc. The Department is well equipped for research in systematic botany, plant anatomy, mycology, algology and hydrobiology.

Résumé of research: The research work that is in progress will be dealt with under the following heads:

1. *Taxonomy and Plant Anatomy*: Work on the Flora of Hyderabad was started in 1930 before which no work had been

done, except for some small work done by the Forest Department. Later on work on anatomy of angiosperms was taken up. More than forty scientific papers have so far been published on problems such as Flora of Hyderabad, structure of pollen grains, anatomy of common Indian herbs and teratology of plants. Investigations on laticiferous tissues in the Asclepiadaceae and the Euphorbiaceae, on morphological and sporodermal layers of the pollen grains in the Compositae, and on the morphology of the Compositae have also been in progress.

It is proposed to explore the natural resources of the Andhra Pradesh by making a survey of the plants of economic and medicinal importance. It is also proposed to carry out a more intensive study of the flora of the State leading to the building up of collection of plants and the publication of an illustrated descriptive account.

2. *Mycology and Plant Pathology*: The problems that are being investigated are: nutritional studies on *Trichoconis crotalariae,* with special reference to vitamin, carbon and nitrogen sources; seasonal variation and distribution of micro-fungi in cultivated, uncultivated and forest soils of Hyderabad; nutritional requirements of parasitic fungi with special reference to *Cercospora personata* and *Trichoconis padwickii;* morphological, cytological and cultural studies of *Setaria* smuts; coprophilous fungi; and studies on the fungus flora of Hyderabad.

It is proposed to make a general survey of pathogenic fungi causing serious diseases of paddy and also study the morphology and physiology of these pathogenic fungi. Investigations on the factors influencing the pathogenicity of these fungi, host-parasite relationships and methods of control, will also be taken up.

3. *Algology and Hydrobiology*: The problems that are being studied are: Systematics of algae; ecological studies on algae, especially soil algae; and physiology of algae with special reference to their trace element nutrition.

It is proposed to carry out intensive limnological investigations on the numerous lakes and ponds in the Andhra Pradesh.

Over sixty scientific papers have been so far published from the Department on the three lines of research mentioned above.

Finance: Generous periodical grants have been received from the University Grants Commission during 1952-57, both for special apparatus and for books.

5. *Department of Botany, Andhra University*:

Botanical laboratories were first organized in the Andhra University in 1937 as a section of Technology mainly fitted for teaching of Pharmaceutical Botany and Pharmacognosy to students taking up Pharmaceutics as a special subject. Some very limited facilities were also developed for research work mainly in Plant Morphology and Embryology by Prof. J. Venkateswarlu, then Lecturer in Botany attached to the Department of Technology. In 1942 the Botany section was transferred to the Geology Department as a part of which it continued to teach Botany as a main and subsidiary subject at the B.Sc. level till 1946. In 1946 a full fledged Botany Department was started under Professor M. O. P. Iyengar. Prof. G. N. Rangaswami Ayyangar succeeded him and until 1951 the laboratories were mainly fitted for teaching Botany at the Honours level. Prof. J. Venkateswarlu succeeded Prof. Rangaswami Ayyangar in 1951 and since then the Department has been equipped to take in a large number of research students working on embryology of angiosperms, cytology, cytogenetics, anatomy, floral morphology, plant physiology, mycology, plant pathology, wood anatomy, palaeobotany and taxonomy.

Staff: One Professor, one Reader, four Lecturers and four Demonstrators.

Teaching and research facilities: Teaching is imparted both at the graduate and post-graduate levels. Training is also given to students to enable them to appear for the B.Sc. Honours degree examination, with cytogenetics as the special subject. Facilities for research in a number of branches of Botany are available and data relating to the award of research degrees in the past are: M.Sc.: 20; D.Sc.: 3.

Résumé of research:

1. *Embryology and anatomy of Angiosperms*: The work on this line was organized initially in 1937. Critical study of the embryology of the Myrtales lends support to the classification of the Myrtales proposed by Engler & Gilg in 1924. Detailed studies have been carried out on the embryology of the Malvales, the embryology and floral anatomy of the Nudiflorae and the Pro-

teaceae, with particular reference to their phylogeny and taxonomy. The embryology of plants belonging to Compositae, Rhizophoraceae, Rubiaceae, Umbelliferae, Gentianales, Acanthaceae, Boraginaceae, Euphorbiaceae, Liliaceae, Commelinaceae, Cannaceae, Iridaceae, Gramineae, Geraniales, Caryophyllaceae, Portulacaceae, Leguminosae and Amaryllideae is also being studied.

2. *Vegetative and Wood Anatomy*: Study of the anatomy of grasses and certain other angiosperms and of some local woods is being taken up.

3. *Cytogenetics and Cytotaxonomy*: A study of meiosis in artificially induced tetraploid maize has been completed, and for the first time elucidation has been obtained, on a quantitative basis, of the pairing behaviour of the pachytene chromosomes in it, bearing on the relation of one exchange on the other, on the relationship of number of exchanges and length of the chromosome, double reduction and non-disjunction phenomena. The cytogenetics of maize and Oriental Maydeae such as *Coix* and *Chionachne*, is also being investigated with a view to find out their inter-relationships and also gain a good knowledge of the morphology of the pachytene chromosomes in them. Similar investigations are in progress on the morphology of the pachytene chromosomes in *Sorghum subglabrascens* (a Eu-Sorghum) and other species of *Sorghum* and *Pennisetum*. Studies of chromosome numbers in Proteaceae have been made and a revision of the ideas about the original home of the Proteaceae has been attempted with data on chromosome numbers, floral anatomy, and distribution. The effect of chemicals on mitosis is being studied; so far, eight new chemicals have been used and it has been found that some of these produce duplication of chromosomes and consequent polyploidy as effectively as colchicine.

4. *Plant Physiology*: Studies have been in progress on some aspects of organic acid metabolism of succulent and non-succulent plants with a view to explain the main differences between plants showing "Crassulacean type of metabolism" and those that do not. Work is also under way on the physiology of storage of bananas at low temperatures and other conditions.

5. *Plant Pathology and Aerobiology*: Recently some work has been started on the dispersion and incidence of spores of fungi pathogenic to crop plants in the air and estimation of minimum isolation distances which will effectively reduce the risk of

healthy crops becoming infected from diseased crops in the same area by air-borne spores.

6. *Flora of the Andhra Pradesh*: Collection of angiospermic plants are being made with a view to gather materials for a local flora and also to provide "neo-types" of plants described by Roxburgh in his work on "Plants of the Coromandel Coast". A Herbarium is being built up in the Department.

7. *Palaeobotany*: Fossil dicot woods from the Cretaceous of Trichinopoly and the Tertiary of Pondicherry and the microflora of Neiveli lignite are being studied. Investigation of the lignite occurring in the Godavari District is also being taken up.

Over sixty scientific papers have been published so far from the Department.

Special schemes of research: An I.C.A.R. scheme for the study of cytology of maize and maize relatives was in progress from April 1953 to March 1956; the observations were mainly confined to cytological studies of maize relatives viz, *Coix aquatica, C. lachryma-jobi, C. gigantea* and *Chionachne.* Another I. C. A. R. scheme for the study of cytogenetics of maize and *Sorghum,* for a period of three years (1957-1960) is now in progress.

There are three Government of India research scholars and one National Research Fellow working in the Department.

6. *Department of Botany, Annamalai University*:

The Department is now in the charge of Prof. T. C. N. Singh who succeeded Prof. T. S. Raghavan as Head of the Department. The work of Prof. Raghavan and his associates was largely on the embryology, developmental morphology and cytology of angiosperms. During the past ten years, efforts have been made to make the teaching of Botany broad-based to include physiology, ecology, palaeobotany, genetics, cytology and taxonomy.

Staff: One Professor, one Reader and two Lecturers.

Teaching and research facilities: Teaching is carried on both at the graduate and post-graduate levels. Facilities for post-graduate research leading to M.Sc. and Ph. D. are also available.

There is a palaeobotanical laboratory, equipped with rock-grinding and cutting machines. A small biochemical *cum* bacteriological laboratory is also being organized.

Résumé of research: In broad outline, the recent investigations include work on the effect of musical sounds on the growth and reproductive phase of plants; lunoperiodism, a new phenomenon affecting flowering of plants; biological eradication of *Saccharum spontaneum;* application of absorption spectroscopy for differentiation of wood quality; radioactivity in plants; cytology of flowering plants in relation to their sex determination; the palaeobotany of Neiveli lignite; studies in the mosses of South India; anatomy of acclimatized conifers of South India; germination and phylogenetic studies of the Leguminosae; the phasic development of plants as affected by vernalisation; photoperiodism; perennation of algae of Annamalainagar; pollination of *Helicteres isora* by sun-birds; influence of X-rays and ultra-violet light on chromosomes of Liliaceous plants; cytology of the mangroves and of musically excited plants; succession of vegetation by line-transect and quadrat methods; climax formations in South India; effect of solar and lunar eclipses on the growth of plants, etc.

Over eighty papers have been published on the subjects mentioned above.

Special schemes of research: Recently, an I.C.A.R. scheme for work on the cytogenetics of pulses was carried out in the Department.

Finance: Generous grants have been received from the Ministry of Education, Government of India and the University Grants Commission and these grants have greatly helped in improving existing facilities for research on the various aspects of Botany already mentioned.

7. *Department of Botany, University College, Kerala University, Trivandrum* :

This Department which was formerly part of the Maharaja's College of Science, Trivandrum, was started in 1926. Two-year post-graduate course leading to the M.Sc. degree by examination was instituted in July 1948. Research students working for the M.Sc. and Ph.D. degrees were admitted from 1949. Admission of students for M.Sc. by research has been discontinued by the University since 1955. At present only candidates possessing a good B.Sc. (Hons.) or M.Sc. degree by examination are admitted for research leading to the Ph.D.

Prof. A. Abraham is the present Professor and Head of the Department.

Staff: One Professor, one Junior Professor and four Lecturers.

Teaching and research facilities: The laboratories are fully equipped for B.Sc. (3-year) and M.Sc. teaching. The number of students admitted to each of these courses is limited to 32 and 10 respectively.

The research section is well equipped for work on Cytology, Genetics and Plant Breeding. There is an excellent photographic section attached to the Laboratory. There is a small Botanical garden attached to the Department with 3,000 sq. ft. of green house space for growing higher elevation plants. The garden already has one of the finest collections of Ferns and rare plants to be found anywhere in South India. The garden is mainly used for growing plants on which research work is currently in progress, and as a live museum of rare plants needed for post-graduate teaching.

In the Library, there are over 2,500 volumes at present and orders have been placed for a large number of rare books on the floras of the world. The Department currently subscribes for 28 Botanical journals, for most of which complete back volumes are available.

There is a Central Herbarium (one so constituted for the Kerala State as a whole) and has 15,000 sheets. There are over 2,000 spp. of flowering plants, nearly all of which have been determined by experts at the Kew Herbarium. There are over 1,000 sheets of Ferns and other lower plants. Periodical additions are being made to the Herbarium, which is under a qualified Curator. It is proposed to expand the Herbarium considerably by providing more space and additional staff. Work on the compilation of a Flora of the State is in progress.

At present there are six research students, three receiving Government of India Senior Scholarships, one receiving a Junior Research Fellowship of the National Institute of Sciences of India, one paid by the I.C.A.R. and another by the C.S.I.R.

Résumé of research:

The following lines of research have been in progress: (1) Cytophylogenetic study of the Pteridophyte flora of South India—This work has been in progress for the last four years. Over 170 species of pteridophytes have already been studied. Seven papers have been published on this subject and the major part of the work is under preparation for publication. (2) Compilation of an illustrated account of the Pteridophytes of South India. (3) Cytological studies on dioecious angiosperms. (4) Cytological and systematic studies of tuber crops of India and their wild relatives (see under special schemes of research). (5) Research on Tapioca, Sweet Potato and other tubers (see under special schemes of research). (6) Cytogenetical investigations on the genus *Chlorophytum* (see under special schemes). (7) Studies on natural and artificial mutations. This work started recently has already given very interesting results and a partial answer to the question of what causes mutations in nature has been obtained. The mutagenic effects of the radioactive sands of Kerala are also under active study. (8) Cytological work on a number of other groups of plants like Orchids and Grasses of Kerala is also in progress. (9) Algal flora of Kerala. (10) Morphological and anatomical studies on Ferns. (11) A detailed study of the valuable plants used in Ayurvedic medicine is in progress.

A number of scientific papers on the subjects listed above have been published.

Special schemes of research : There are three special schemes of research in progress.

1. Scheme of research on tapioca and other tuber crops of India: This scheme with an annual expenditure of Rs. 60,000 is jointly financed by the Kerala Government and the I.C.A.R. Important results of practical value to Indian agriculture have been obtained. Four high-yielding varieties of tapioca have been evolved by intervarietal hybridization and selection. Work on the artificial induction of mutations in tuber crops is in progress.

2. Scheme of research on miscellaneous tuber crops of India: This scheme with an annual expenditure of Rs. 7,500 is wholly financed by the I.C.A.R. The work is conducted in the Botany Department and the Tuber Crop Experiment Station, Trivandrum. This deals with the collection of all varieties of tuber crops cultivated in India and other tuber bearing plants closely related to these. Cytological investigations are carried out on all the materials collected. This is supplemented by morphological studies to aid in a proper classification of the materials, so that suitable genetical stock would be available for further

work on the improvement of tuber crops in India. The live collections are maintained at the Tuber Crop Research Station, Trivandrum. An account of the Tuber Crops of India giving all available information on the same is being compiled for publication.

3. Scheme of research on the cytogenetics of the genus *Chlorophytum*: This scheme, financed by the C.S.I.R. and with an annual expenditure of Rs. 7,000 deals with a fundamental study on the cytogenetics of a small Liliaceous genus. The object is to find out by cytogenetical methods the probable manner in which speciation has taken place in this genus.

Finance: In addition to the funds made available by the I.C.A.R. and the C.S.I.R., equipment and library grants have been received from the University Grants Commission and the Ministry of Education, Government of India. This is supplemented by grants from the Kerala University for recurring expenditure and normal expansion.

8. *Botany Department, Karnatak College, Dharwar*:

The Karnatak College, Dharwar, is affiliated to the Karnatak University. Botany came into its own in 1948 with the beginning of teaching of Botany as a principal subject at the B.Sc. level. The history of the development of the subject in the University is thus limited to the last nine years. Post-graduate instruction in Botany for the M.Sc. degree by examination was started in 1951. In addition, a number of students were admitted for the M.Sc. degree by research.

Prof. L. K. Gungikar, Head of the Department of Botany, is also Professor-in-charge, post-graduate instruction in Botany, Karnatak University.

Staff: One Professor and three Lecturers.

Teaching and research facilities: Teaching is carried on both at the graduate and post-graduate levels. The Karnatak University on whose behalf the Karnatak College conducts post-graduate instruction has provided one Demonstrator to assist in practical work; otherwise, the entire work is carried out by the Botany Department staff with the assistance of two other recognized teachers of other Colleges. There is no special staff for research.

Résumé of research:

1. Desmidiaceae and Cyanophyceae of the Bombay-Karnatak: Systematic study of the freshwater desmids and of various Cyanophyceae of the Bombay-Karnatak has been carried out.

2. The Oedogoniales of the Bombay-Karnatak have also been studied.

3. Embryology and Cytology: Embryology and cytology of *Anogeissus latifolia, Terminalia tomentosa* and *Combretum ovalifolium* have been investigated. Micro- and megasporogenesis, the development of ovules and the origin of the tapetum in these species have also been studied.

4. Ecology and seasonal aspect of the phanerogamic flora of the irrigation tanks about Dharwar. Four tanks were selected for study of the aquatic plants over a period of two years. The seasonal variations in the floral composition of these tanks have been investigated and an attempt has been made to correlate the occurrence or absence of certain plants with the edaphic, physiographic and biotic factors. The possible lines of succession in these tanks are also mentioned. An abstract of one part of this work has been published in the Abstract copy of the symposium on the "Vegetation Types of India" held at Baroda in 1953.

5. Investigations on the following subjects are also in progress: the Bryophyte flora of the Bombay-Karnatak; the Lichen flora of the Bombay-Karnatak; the autecology of some weeds around Dharwar; stomatal studies on plants; and vegetative reproduction in succulent plants.

A number of scientific papers have been published.

9. *Department of Botany, Sri Venkateswara University, Tirupati*:

The Sri Venkateswara University at Tirupati (Andhra Pradesh) was recently established. The Department of Botany is not a full fledged one and is just a section teaching Botany at the Subsidiary level. It is attached to the Department of Zoology and there is a lecturer who is in charge of teaching Botany.

10. *Sugarcane Breeding Institute, Coimbatore*:

The Sugarcane Breeding Station (now Institute) was established in 1912. The low acre yields of the indigenous cane varieties and the large imports of foreign sugar causing a drain on the financial resources of the country led to the founding of this breeding centre for evolving improved hybrid varieties to replace the indigenous varieties in the sub-tropical areas of India, wherein lies the bulk of the sugarcane area. The Breeding Station was located at Coimbatore since cane varieties flowered and set seed freely at this place.

At its inception, the Station was under the administrative control of the Director of Agriculture, Madras, with aid of funds provided by the Government of India. The Government of India took over the Station in 1924 and for many years it formed a part of the Imperial Agricultural Institute, Pusa (now Indian Agricultural Research Institute at New Delhi). With the taking over of the Station directly by the Government of India (Ministry of Food & Agriculture) in 1950, its status was raised to that of an Institute.

Staff : The Head of the Institute is the Director who is also in charge of the breeding work. He is assisted by seven officers dealing with different aspects bearing on the breeding work, viz., Breeding, Cytogenetics, Botany, Physiology, Chemistry, Mycology and Entomology. There is also a nucleus staff on the Statistical and Meteorological sides. The Institute has a Sub-Station located at Karnal (Panjab, India) in sub-tropical India under an Assistant Botanist.

Shri Nand Lall Dutt is the present Director of the Institute.

Training and research facilities : The functions of the Institute are : (i) to breed improved sugarcane varieties for all the cane tracts of the Indian Union, (ii) to conduct fundamental research on the botany and cytogenetics of sugarcane and also on certain physiological, chemical, mycological and entomological aspects of sugarcane, and (iii) to impart post-graduate training in sugarcane breeding and botany.

The Institute offers three post-graduate courses to impart specialized training in sugarcane, viz., (i) Plant Breeding and Genetics, with special reference to sugarcane (2 years); (ii) Agronomy with special reference to sugarcane (2 years); and (iii) one-year course in Sugarcane Breeding. The former two courses are at present being conducted in collaboration with the Indian Agricultural Research Institute, New Delhi. In addition to the above, there is a short course of three to four months' duration for those actually engaged in sugarcane work in Government Departments, factory estates or private farms. A few suitable candidates are also permitted to do research work (Honorary) under proper supervision and guidance and submit theses for the M.Sc. and Ph.D. in Botany to the Madras University. Certain students from other countries also have availed themselves of the one-year course and the short course of training.

Résumé of research: Ever since its inception, the Institute has been actively engaged in the breeding and evolving of improved varieties for sub-tropical India and since 1926, for the tropical parts also. Success in this work has been achieved by breeding varieties combining in themselves as many desirable characters as possible from a wide range of parents. This has involved the use of all the species of *Saccharum* and even related genera in the breeding programme. Much improvement in technique has also been effected over the last four decades.

In the normal work of the Institute, a large number of crosses are annually effected between carefully selected breeding canes. Every year about 80,000 to 100,000 seedlings are raised. A rigorous selection is made among the seedlings of each annual batch over 3-4 years on the basis of their agricultural and commercial qualities, and those finally selected are sent out to Sugarcane Research Stations in the various States in the Indian Union for being tested in their respective sugarcane areas. Those which show a distinctly superior performance in the States are released by them for general cultivation. New and better varieties are thus sent out from Coimbatore constantly to replace the old. The improved sugarcane varieties bred at the Institute (Co. canes) now occupy 90 per cent of the sugarcane area in the Union. Six of the main varieties in cultivation are Co.312, Co.313, Co.419, Co.421, Co.453 and Co.527.

In the evolution of new varieties, which is the principal function of the Institute, the breeding section is assisted by the other scientific sections. In all these, including the breeding section, research work is carried out for improving the efficiency of breeding, raising better quality material and getting information useful in selecting right type of seedlings.

In the Cytogenetical section, studies have been in progress during the past 25 years. These have shown sugarcane to be a highly heterozygous polyploid complex, with certain peculiarities of cytological behaviour. In recent investigations, certain peculiarities like diploid parthenogenesis, elimination of chromosomes *en bloc,* non-segregation of parental characters due to auto-syndetic pairing, etc. have been noticed. Work has been in progress to understand the genetical constitution of *Saccharum officinarum* and the homology of its chromosomes.

The success achieved in the production of improved varieties of cane especially for sub-tropics has been largely due to the use of the wild sugarcane (*Saccharum spontaneum,* Kans grass) as a parent in hybridization. This wild cane confers many desirable characters like hardiness, vigour, disease resistance, etc. on the progeny and this species has been, therefore, studied in detail in the Botany Section since 1949. Hundreds of varieties of this cane have been collected from various parts of the Indian Union and from almost all countries of tropical and sub-tropical Asia and Africa. Work is in progress on variation patterns in the species, and the breeding value of the variants as parental stocks. A World Collection of Sugarcanes consisting of hundreds of cultivated cane varieties from Melanesia, Indonesia and other parts of the world has been established at the Institute. This provides a vast store of desirable breeding material for use in breeding.

Among the sections most closely concerned with varietal selection work is the Chemistry Section where thousands of analyses are made every year to assess the juice quality of seedling varieties at various stages of selection. Surveys of juice quality and milling behaviour of varieties in cultivation in the various factory zones are also conducted. Besides this, the chemical composition of the sugarcane juice as it affects the quality of gur and white sugar is being studied with particular reference to total nitrogen, protein nitrogen, ash and colloids.

For improving the range of crossing, it is necessary that non-flowering varieties should be made to flower and the flowering time of varieties should be controlled. This problem is being tackled in the Physiology Section which was started in 1942. A substantial degree of control over the time of flowering in several varieties has been obtained through a series of photoperiod experiments. Marked varietal differences in response to various photoperiods have been observed. Plants can now be rendered vegetative by extra light treatment and brought to a flowering condition whenever necessary by extra dark treatment, In the Mycology Section, which came into existence in 1946, red rot resistance ratings of all new evolved varieties in the Final Test Plot are determined by artificial inoculations. Similar tests are being conducted for resistance to the smut disease as well. Investigations are also in progress on mosaic, root rot, and other cane and seedling diseases.

Observations on the field incidence of pests and experiments on insecticides for control of termites and borers and study of their phytotoxic effects are being carried out in the Entomology Section, which has been functioning since 1946. Both the Mycology and the Entomology Sections keep a close watch on the varietal plots and also check the phytosanitary condition of the cane material imported or exported by the Institute to other States or foreign countries.

At the Sugarcane Sub-Station at Karnal, a live Herbarium is being maintained, and morphological descriptions of Co. varieties are recorded. The reaction of varieties to frost is studied. Co-ordinated seedling selection work has also been started.

Liaison and information: The Institute maintains close relations with other research Institutions in India and abroad, particularly those connected with sugarcane. Excellent exchange relationship is maintained with many sugarcane growing countries in the matter of plant material of varieties. The Institute also gives advice freely to cane growers and the industry, whenever such advice is sought.

Finance: The Institute and its Sub-Station are financed entirely by the Government of India.

11. *The Botanical Survey of India, Southern Circle, Coimbatore*:

The Botanical Survey of India is an organization under the Ministry of Education and Scientific Research of the Government of India. It has its headquarters at Calcutta with four regional circles, a Central Botanical Laboratory at Lucknow and an Industrial Museum at Calcutta. The office of the Southern Circle, Botanical Survey of India, which was started in October 1955, is located at Coimbatore and has under its jurisdiction the States of Madras, Andhra Pradesh, Hyderabad, Madhya Pradesh and Vindhya Pradesh (Division of States as before November 1, 1956).

The Survey primarily has three functions: (i) the collection and identification of all the plants coming under the jurisdiction of the Circle; (ii) the building up of a Regional Herbarium; and (iii) the formation of a National Herbarium which will house the "type specimens" and a fully representative collection of plants comprising the flora of India.

The Southern Circle is in the administrative charge of Dr. K. Subramanyam, Regional Botanist.

Staff: One Regional Botanist, one Systematic Botanist, one Scientific Assistant, one Herbarium Assistant, two Fieldmen and two Mounters. More staff will be recruited as the work of the Circle expands in future.

Teaching and research facilities: The plant collections in the Herbarium are arranged according to the system of Bentham & Hooker. Carpological collections are also made. It is proposed to have an experimental garden and a small museum attached to the Herbarium in due course. The Library is being gradually built up and a number of Indian and foreign periodicals in Systematic Botany and allied branches are being subscribed for. The Circle offers facilities to University teachers and students for identification of their plant collections. Provision will also be made for students to carry out post-graduate work leading to M.Sc. and Ph.D. in taxonomy and closely related subjects like cyto-taxonomy, vegetative and floral anatomy, and embryology in relation to systematic botany. Finally, it is proposed to arrange lectures and short courses, in the rapidly expanding Regional Herbarium, on the methodology of plant exploration and survey, taxonomy and related subjects, with a view to create a zest and interest among the scientists and interested persons for research.

Résumé of research: In the year 1956-57, intensive plant collections were made in the following unexplored regions of Coimbatore Taluk and the under-explored regions of Nilgiris District, during the several seasons of the year. In Coimbatore Taluk plants were collected from Varapalayam, Kurudimalai (Lampton's Peak), Chinnathadagam, Marudamalai, Thekkumalai, Vellingiri and Siruvani; plant exploration was carried out about Kotagiri and Coonoor in the Nilgiris District. During the current year exploration work is in progress in Courtallam, Singampatti, Alagar Hills, Hulikal Droog Reserve and Pakkasuramalai; in addition to this, the mangrove vegetation at Pichavaram and Kolleru lake for the study of aquatic plants will also be undertaken.

Collections of plants are extensively made from several habitats and in different stages of growth. The collections exceed so far a little over 20,000 specimens. The plants are collected in replicates of six; of these, two sheets are mounted for the Regional Herbarium and two for the Central National Herbarium, Calcutta, and the remaining two intended for exchange purposes. During collection of these plants particular attention is paid to the economically important and medicinal plants. Further, taxonomic studies are made with a view to find out the possibility of introduction of new economic and other useful plants which occur wild in forests.

CHEMISTRY

The first landmark in the growth of Chemical research in South India was the founding of the Indian Institute of Science at Bangalore in 1912 with a band of renowned Chemists like Travers, Sudborough, Fowler, Watson and others. For nearly half a century this institution has been attracting the best talents in this country and has played no mean part in training scientific personnel required to man our various research institutions, universities and industry which have sprung up in recent years. The Presidency College, Madras, a premier educational institution in the South, slowly but steadily built up a school of Organic Chemistry under the guidance of distinguished professors like Sir J. L. Simonsen, F.R.S. and Dr. B. B. Dey. The University of Madras even in the earlier parts of this century was not slow to make its contribution to the promotion of research. As a first step, Studentships and Fellowships were instituted to enable students to work in the above institutions. Subsequently the role of this University in the fostering of research became more active and significant when it decided to open its own departments of research. The University now maintains nearly thirty departments of study and research among which there are three for Chemistry—Biochemistry, Organic Chemistry and Physical Chemistry, besides the Chemical Technology Section of the University Alagappa Chettiar College of Technology. This phenomenal progress has been due no less to the initiative, vision and guidance of the present Vice-Chancellor than to the substantial endowments and large number of studentships and fellowships made available by the Central Government and its auxiliary bodies like the University Grants Commission, Council of Scientific and Industrial Research, etc. Besides the Presidency College, other constituent colleges like the Madras Christian College and the Loyola College have also established in recent years schools of research in Chemistry. The newer universities of the South—Andhra, Annamalai, Kerala, Mysore, Osmania and Sri Venkateswara—have also made remarkable progress in Chemical research. Besides, three of India's National laboratories are located in this region—Central Laboratories at Hyderabad, Central Electrochemical Research Institute at Karaikudi and Central Leather Research Institute at Madras. Though of recent origin, these institutions have already established their reputation for research of high quality.

The following sections survey the facilities available for research in Chemistry, the fields of specialization, and the results achieved at the above mentioned centres of research.

A—UNIVERSITY OF MADRAS:

I. *University Departments of Chemistry*:

Of the three Departments of Chemistry maintained by the University, the Biochemistry Department was started about 25 years back. As the work of this department is being reviewed in another section of this brochure, no further mention is called for in this section.

a. *Department of Organic Chemistry*: This Department was opened in 1950 and has since developed into a well-organized and well-equipped department for research in higher Organic Chemistry. Facilities exist for about fifteen research students. The department has been engaging itself in work relating to the isolation and structure determination of the active principles of vegetable drugs, synthesis of heterocyclic and condensed ring systems, studies on certain aspects of stereochemistry, etc. Among the important results achieved may be mentioned (1) the preparation of a few 3: 4 quinozolonyl quinazolines which are structurally analogous to alkaloids, Evodiamine and Rutae carpine; (2) the development of a new method for the preparation of indole -3- aldehyde, (3) synthesis of 3- methyl isotryptophanes; (4) synthesis of new derivatives of isoquinoline; (5) study of the conditions of addition of thioglycolic acid to unsaturated compounds; (6) synthesis of tetralone derivatives; (7) preparation of compounds having structural features in common with steroid hormones; (8) study of terpenes like longifolene; (9) study of vegetable drugs like *Cyclea burmani* and *Cryptolepis buchanani.* The department has published about 20 papers in various journals.

b. *Department of Physical Chemistry*: This department, opened in 1952, can take about 12 students for research. The department has chosen high polymer chemistry as its field of specialization. The subjects of study comprise (1) Photosensitized free radical polymerisation of vinyl compounds (2) spectro-photometric investigation of the complexes of ferric ion with oxalic and citric acids (3) chain transfer reactions and the nature of initiation in the polymerisation of styrene (4) rates of initiation and chain transfer constants in the polymerisation of methyl acrylate (5) methyl ethyl ketone peroxide as an initiator in vinyl polymerisations; (6) synthesis of tetramethyl phenols and study of their reaction with formaldehyde, from a physico-chemical point of view; (7) mechanism of oxidation of organic compounds by ceric salts; (8) viscometric and osmometric study of high molecular weight compounds. New lines of investigation planned include study of the catalysts of polymerisation with catalysts containing radio-active atoms, photochemical amination and hydroxylation of organic compounds, studies on the fluorescence and oxidation properties of excited uranyl ions, etc. About 20 research papers have been published so far.

c. *Department of Technology*: As a complete account of the Alagappa Chettiar College of Technology is given elsewhere in the brochure, only a reference to the problems of chemical interest investigated in the department is being given in this section.

Apart from the study of unit operations and process research in Chemical Engineering, and investigations on the Chemical utilization of Neiveli lignite, the department has interested itself in and made many publications on (1) the preparation of synthetics such as nitriles and amines from fats and oils, on which a patent has been awarded, and (2) newer techniques in analytical chemistry. In this field, many of the newer techniques have been successfully applied to new estimations—coulometry to many aqueous and non-aqueous solutions, amperometry for estimating germanium, molybdenum, chromium, etc., colorimetry in the estimation of tin and copper, a new polarographic method for analysing "Stand fast" low melting alloy used in the modern process of dyeing textile fabrics. The recent expansion of the chemistry section bids fair to enhance the output of work in chemistry and applied chemistry.

II. *The Presidency College, Madras*:

The tradition for research in Organic Chemistry in the Presidency College was built up mainly by two of its previous Professors, Sir J. L. Simonsen who conducted classical work in terpene chemistry in the years 1910-1918 when he was the additional professor and Prof. B. B. Dey whose work ranged from synthetic organic chemistry to the study of natural products and enzymes. Under Prof. Dey's guidance were also developed two lines of research, (1) chemistry of gland products and (2) electro-synthesis of dye-intermediates.

Under the present Professor of Chemistry, the research activities of the department have been progressing at a rapid pace. Extension of laboratories, acquisition of up-to-date equipment and the availability of a larger number of studentships have all contributed to raise the tempo of the work of this department.

The research activities of the department are primarily connected with the chemistry of plant products, comprising the isolation of plant constituents, elucidation of structure of new compounds encountered and synthesis wherever feasible of the natural products. A second line of work is concerned with synthesis of potential curarimimetic and spasmolytic drugs. Important contributions from the department are elucidation of the structure of carpaine, of wedelo-lactone, of gentiamine and of tylophorine. During the last four years, thirty-five papers have been published in leading scientific journals. During the same period the number of theses submitted for M.Sc. and Ph.D. are respectively nine and ten.

The Department is also engaged in work connected with a scheme on Indian medicinal plants sponsored by the C.S.I.R. and another on Ayurvedic drugs sponsored by the College of Integrated medicine.

III. *Madras Christian College, Tambaram*:

During the last fifteen years the department has been engaged primarily in developing a school of Physical chemistry with all the members of the teaching staff and a succession of whole time students. The problems studied have been largely concerned with reaction kinetics and inter-molecular and intra-molecular forces. The hydrolysis of esters has been studied in alkaline and acid conditions in a variety of solvent mixtures. The results obtained so far have clearly shown that the reaction is primarily an ion-dipole reaction and solvent influences show that besides the dielectric constant and viscosity, short range forces and the structure of the liquid system has also to be taken into account. The bromination of olefines has also been noticed to be quite a complex reaction and in nonpolar environments, polar surfaces and polar catalysts play varying roles. The producst of the reaction also have been definitely found to modify the reaction. Another reaction studied is the formation and decomposition of onium compounds and here too complex solvent influences are noticed even if one were to confine studies to the region of homogeneous conditions. A study of the physical properties of dilute solutions has formed a complementary part of reaction kinetics studies and the dipole moments of a number of compounds have been measured in more than one solvent revealing specific group interactions involving the hydrogen of an alkyl group as also deviations from ideal behaviours even with extremely dilute solutions, such deviations being beyond the limits of experimental error. The work from these laboratories has been published mostly in the Proceedings of the Indian Academy of Sciences and some of the work has appeared in Current Science, Journal of Scientific and Industrial Research and in the Journal of the Madras University. The work done has formed the basis of several theses for the higher degrees of the Madras University.

There are two research scholars getting the Government of India Senior Research Studentships and generally one studentship of the University of Madras is awarded to a research student working in the Department. During the period 1953-57, grants from the Government of India of Rs. 7,500 for equipment and Rs. 2,000 for books have been received and some of the chemicals used in the work have been obtained from a few firms like the I. C. I. as gifts, besides two grants from the Chemical Society, London.

IV. *Loyola College, Madras*:

Since the year 1948 this college has developed into an active centre of research in Chemistry.

The Department has completed a comprehensive study of the structure and properties of the phenolic constituents of Cashew nut shell liquid, comprising (1) the separation and establishment of structure of the diolefinic component of cardanol, (2) separation of the components of anacardic acid, determination of their constitution as well as that of cardol obtained by molecular distillation and (3) thermal and catalytic cracking and autoxidation of cardanol. Indian turpentine oil forms another field of study in which are included (1) studies on the conditions of conversion of 3-carene into different products like p-and m-cymenes, alpha terpinene, etc. (2) catalytic conversion of alpha - pinene into O-

and p- cymene, (3) aromatisation of terpineol, (4) pyrolysis of longifelone to yield useful aromatic hydrocarbons, etc. Polymerisation studies conducted in this department comprise dimerisation and tetramerisation of 3- carene, chromatographic study of the kinetics of the phenol-formaldehyde reaction, etc. In gas kinetics, work has been done on the kinetics of the thermal decomposition of metal alkyls the reactions being interpreted on the free radical mechanism. In solution kinetics, research has centred around bromination of aromatic compounds in aqueous and non-aqueous solvents and the elucidation of their mechanism.

There are fourteen research scholars working in the department of whom six receive scholarships from the Government of India, University or C. S. I. R. So far seven students have qualified for the M.Sc. degree and two for Ph.D.

B. The Annamalai University :

While Chemical research in this University started almost from its year of inception, 1929, work has been proceeding at a more accelerated pace since 1952 when the present Professor of Chemistry was appointed to his post. During the last five years fourteen students have qualified for the M.Sc. degree (by research) and four for the Ph.D. degree, and about forty three research papers have been published. Organic research in the last five years has been concerned with hetero-cyclic compounds, organo-sulphur, organo-selenium, organo-mercury and organo-phosphorus compounds, absorption spectra of organic compounds, and a study of steric and polar effects. Physico-chemical work has been in the fields of reaction mechanisms, liquid dielectrics, and conductivity of liquid mixtures and strong electrolytes. The results so far achieved may be summarized under the following heads: (1) Synthesis of new piperidines and pyridines, (2) synthesis of unsaturated sulphones and amino=sulphones, (3) preparation of 1 : 4 thiazines by a new method, (4) application of Fries reaction to the preparation of phenolic sulphones, (5) proof for the expansion of the valency shell of sulphur, (6) elucidation of the mechanism of Mannich and Knoevenagel reactions, (7) elucidation of the nature of sulphur-oxygen bonds in sulphones, (8) evidence for the existence of chelation of O-hydroxy sulphones, (9) elucidation of the nature of electronic excitation in diaryl sulphides and para polyphenyl sulphides, (10) development of substitute reagents for Zimmerman=Reinhardt reagent,

C. KERALA UNIVERSITY:

The University of Travancore, out of which has evolved the Kerala University, has been maintaining a Central Research Institute in which Applied Chemistry forms a department. Within the university area there are also two colleges with Honours and post-graduate courses in chemistry—the University College, Trivandrum (now taken over by the State) and the Maharaja's College, Ernakulam. The college at Trivandrum has considerably augmented its equipment through the liberal grants received from the Government of India in the First Plan period, and can now be expected to make research one of its main functions.

I. The Department of Applied Chemistry

This Research Institute has been doing substantial work both in pure and applied chemistry, with an emphasis on the utilization of indigenous natural products. The main lines of the work with a summary of the results achieved are given below :

1. Chemical investigations of forest products, chiefly medicinal plants, oil seeds and essential oils. One of the findings, that the "White variety" of lemon grass does not contain citral, has been of use to this important industry. The fibre of *Helicteres isora* is capable of development as a substitute for jute.

2. Researches on marine products resulted in the establishment of a shark liver oil factory (before 1950) using an antioxidant developed here. Methods have been worked out for the production of alginic acid and mannitol from *Sargassum* sea-weed, insecticides from low-grade fish oils and high protein (95% protein) concentrates from cheap fish meal.

3. Mineral resources. Two new methods have been worked out for processing monazite sands by the use of easily available chemicals with recovery of bye-product superphosphate. A model salt factory was maintained and conditions for the production of high quality common salt were worked out.

4. Coir and Coco-nut products were investigated and a possible use for Coco-nut pith, at present a waste, was worked out for the manufacture of insulating boards.

5. Wood tar and Coco-nut shell tar. Preliminary investigations on their use for the production of plastics were carried out. One of the insecticides obtained from them is as efficient as D.D.T,

6. Soil Chemistry. Extensive waste 'Kari' soils of the State are quite unproductive due to its high acidity. Work in this department has shown that by the use of chalk, the acidity can be remedied and now considerable areas are under cultivation using this method.

7. Investigations on indigenous medicinal plants. Several plants have been subjected to preliminary investigations and a good many, to intensive research. An alkaloid, chonemorphine, after encouraging pharmacological work, is being subjected to clinical studies in a Madras hospital. The chief alkaloids of *Vinca rosea,* serpentine, and rauvolfia type alkaloids is being pharmacologically examined in the Drug Research Laboratory, Jammu.

8. Efforts to find an oral remedy for diabetes begun in 1954 are being vigorously pursued by many Ayurvedic physicians. The results of their work, at present without a firm scientific basis, have already shown that, if encouraged and directed in a scientific manner, very substantial results can be achieved.

9. Investigations in Physical Chemistry: The kinetics of the solvolysis of benzyl chloride catalysed by mercuric chloride is being studied.

The results of the work done since 1950 have been embodied in about 50 bulletins of the Central Research Institute. Over twenty papers have been published in various scientific journals.

The Department has on hand two schemes sponsored respectively by the Central Arecanut Committee and by the I.C.A.R. The Department has prepared plans for (1) an extensive series of researches on Ayurvedic drugs, embracing their chemical, pharmacological, clinical and technological aspects, (2) production of commercial products like starch, glucose, and citric acid from tapioca, (3) improvement and standardization of the methods of production of cashew nut shell liquid.

II. *The Maharaja's College, Ernakulam* :

This institution teaches chemistry to the B.Sc. (Hons.) standard and is also affiliated for a post graduate M.Sc., degree course in two branches of Applied chemistry, viz., Pharmaceutical chemistry, and Oils, fats and aromatics. Over twenty papers have been published from the department in the last ten years, the bulk of them relating to studies on natural fats, a few on aspects of synthetic organic chemistry and a few others on essential oils. Provision has been made for a grant of Rs. 3·5 lakhs in the second plan period which would bring in greater facilities for research in all branches of chemistry.

D. ANDHRA UNIVERSITY:

Department of Pharmacy: The Pharmaceutical chemistry section of this department has been working on a C.S.I.R. scheme on "Chemical Investigation of Indian cardiac drugs". The Chemical components of North Indian squill (*Urginea indica*) are shown to be very different from South Indian squill (*Scilla indica*). From Kashmir *Digitalis lanata,* B-acetyl digoxin and digitalinum verum have been isolated. *Cerbera odollam* and *Thevetia neriifolia* of South India have been shown to contain the same major crystalline components. Under an I.C.A.R. scheme, the possibilities of better utilization of arecanut are being explored. Other investigations include (1) the chemical examination of *Rhododendron* species (2) the study of indigenous lichens, indigenous leguminous insecticides, fish poisons, etc.

E. THE OSMANIA UNIVERSITY, HYDERABAD:

The Chemistry Department is well equipped for research in all branches of the subject, thanks to an overall grant of Rs. 2·3 lakhs from the Central Government during the first plan period and periodical grants from the University.

During the last ten years the output of research has been substantial as the following summary will show.

Inorganic Chemistry: (1) Studies on complex formation in compounds of cobalt, nickel, chromium, iron and molybdenum (2) studies on the co-deposition of cobalt and nickel, iron and nickel, and iron and cobalt, including working out of the optimum conditions of co-precipitation.

Physical Chemistry: (1) Studies on thermal decarboxylation of aromatic acids (2) spectrophotometric and electrometric investigations on complex formation (3) Photolysis of hydrogen peroxide (4) Dissociation constants and hydrolytic studies.

Organic and Biochemistry: (1) Synthesis of physiologically active aromatic and heterocyclic compounds containing halo and nitro groups. Synthesis of many derivatives of methoxy cumarones and coumarins (2) Isolation and study of the Chemical compounds of plant materials (3) studies on the formation of heterocyclic rings (4) preparation and applications of organometallic compounds (5) heterocyclic N-oxides (6) chemical examination of agricultural residues like bagasse, groundnut shells, etc.

The department has on hand a C.S.I.R. scheme on plant insecticides and an I.C.A.R. scheme on study of the rate of decomposition of insecticidal deposits.

F. SRI VENKATESWARA UNIVERSITY, TIRUPATI

This new University, just three years old, may be considered to be still in its formative stage. The Chemistry Department has undertaken the following investigations: Studies on (1) Plant colouring matters (2) Thermodynamic properties of non-aqueous systems (3) Eder's reaction (4) Induced reactions (5) Organic reagents in inorganic analysis.

G. INDIAN INSTITUTE OF SCIENCE, BANGALORE

It cannot be expected that in a short note adequate justice can be done to all the phases of chemical research conducted in this premier All-India research institute during the forty five years of its existence. The following account is, therefore, written laying greater emphasis on the work of the past ten years. The institute maintains two Departments of Chemistry, General and Organic. These departments have the objectives of (1) training research workers along right lines (2) investigating technical schemes sponsored by Governments and other organizations and (3) offering technical advice to industrial concerns.

I. Department of General Chemistry:

The main problems on which research was carried out prior to 1948 comprised the following schemes; all sponsored by C.S.I.R. Studies on (1) Beryllium and its alloys; (2) synthetic methanol (3) Industrial catalysts (4) Butadiene (5) Hydrogen peroxide (6) Di-electric constants of liquids (7) Plastics from vegetable oils (8) Ultrasonic velocity in gases and vapours (9) cytogenetics of yeast and fungi (10) Electric furnace treatment of coal (11) Manufacture of sodium and magnesium (12) Beneficiation of gypsum and phosphates (13) The properties of rubber latex.

The highlights of the work in the last ten years have been (1) High pressure reactions, including preparation of propionaldehyde by oxo-synthesis, synthesis of carboxylic acids, catalytic hydrogenation of low temperature tars, preparation of liquid fuels from ethylene, preparation of aliphatic amines, etc. (2) Polarography comprising the polarographic behaviour of organic compounds like iodo compounds, nitrophenols, etc., inorganic compounds including metallic complexes, and the development of a method for the estimation of thionates (3) Electro chemical studies involving the development of new types of plating baths and a study of their characteristics; work on the inhibition of the corrosion of aluminium, development of electrochemical methods of preparation of hydrosulphite and hydrochloride (4) Adsorption studies on catalysts, adsorption of pure and mixed gases on pure and promoted catalysts of technical importance, over wide ranges of temperature. This work is of special significance in giving an insight into the mechanism of technical reactions like Fischer—Tropsch and ammonia syntheses correlating adsorption and catalytic activity and throwing light on the effect of promoters, poisons and supports (5) Utilization of mineral resources, including beneficiation of ores, study of principles of froth flotation. A thermal method of converting rock phosphate into citrate soluble phosphate also has been worked out. Besides these specialized lines the department has conducted general inorganic researches on a variety of problems—work on the suboxides of sulphur, peroxy titanium compounds, carbides of titanium, hydrochloroceric acid, etc. On the analytical side, methods have been developed for estimation of lithium, thorium and sulphur compounds, of spectrophotometric estimation of micro quantities of thorium and uranium and for the separation of metallic ions by circular paper chromatography.

The post-graduate output in the period 1948-57 numbers thirty-five of whom two qualified for the D.Sc. degree, eleven for Ph.D., six for M.Sc. and sixteen for A.I.I.Sc.

II. Department of Organic Chemistry:

This department has conducted research in almost all branches of organic chemistry—oils and fats synthetic drugs, synthesis of natural drugs, essential oils, terpenoids, heterocyclics, carbohydrates, etc. Investigations on the constituents of a number of Indian essential oils, determination of the structure of natural terpenes and synthesis of azulenes formed a phase of the earlier work of the department, initiated in 1914. Oils and fats have also received attention from the inception of the department. As a result of this line of work, adsorption chromatography was developed as a method of refining oils and of extracting non-fatty constituents. A large number of organic reactions have been studied intensely with a view to the elucidation of their mechanism. In heterocyclic synthesis quinilinoquinoline and quinazoline have been synthesized. Experiments on the synthesis of steroids and non steroids, sesamin, sesamolin, reserpene, and penicillin are in progress. A stereospecific synthesis of equilenin has been achieved. In the field of carbohydrates, the gross structure of fructosan from *Agave vera-cruz* has been established. Work has also been done on the constituents of the tuber, *Crinium longifolium* and the fruits of *Cordia myxa.*

Nineteen students have qualified for the Ph.D. degree, four for M.Sc., one for F.I.I.Sc. and eighteen for A.I.I.Sc. in the last ten years.

H. THE CENTRAL ELECTROCHEMICAL RESEARCH INSTITUTE, KARAIKUDI

This institute is one of India's National Laboratories established by the C.S.I.R. with the dual purpose of promoting scientific endeavour in the country and for providing the research background required for the electrochemical and electro-technological development of the country. The institution owes its establishment to the munificence of the late Dr. Rm. Alagappa Chettiar who donated fifteen lakhs of rupees and three hundred acres of land.

The research programme of the Institute has been formulated in relation to the needs of the electrochemical industries of the country—existing and projected. Greater emphasis is naturally placed on the applied aspects of the subject rather than on fundamentals.

Immediately after its inception in 1953, the institute launched on a research programme with the following as its highlights (1) The utilization of Neiveli lignite for the electro-thermal production of calcium carbide (2) The production of electrolytic manganese from low grade ores (3) Electrolytic production of titanium metal (4) Electrolytic recovery of pure lead and pure antimony from battery wastes and (5) Development of processes for the electrolytic production of technically important inorganic and organic compounds like cuprous oxide, ammonium persulphate, manganese dioxide, sodium hydroxide and sulphuric acid for rayon industry from sodium sulphate, aminophenols, calcium gluconate, etc. Other problems of study included the anodization and finishing of aluminium, hard chromium plating of bearing surfaces for internal combustion and locomotive engines, etc. Studies have been made on the production of improved types of lead batteries, nickel-cadmium accumulators, and electrodeposition of cobalt-tungsten alloys.

On the preparative side, the technique of using the rotating electrode in electrochemical preparations, is a significant contribution of the institute, which permits the use of higher current density thereby increasing the production capacity of cells. Many of the processes and products developed are awaiting commercial exploitation.

Recently the following new schemes have been initiated to fit in with the development schemes of the second plan period.

1. Electrochemical production of lead from Sawar ore concentrates.
2. Electrolytic oxidation of toluene to benzaldehyde.
3. Preparation of cupric hydroxide and copper powder for use in anti-fouling paints.
4. Development of improved types of dry cells.
5. Electrochemical studies on protection conferred by different metal finishing treatments.
6. Corrosion of metals and metallic couples under tropical conditions.
7. Preparation of lead peroxide electrodes for use in place of platinum.
8. Kinetics of electrode processes:
    - a. Anodic behaviour of metals.
    - b. Reactions at rotating electrodes.
    - c. Studies on the redoxo-kinetic effect.
    - d. A. C. polarography.

During the four years of its existence the Institute has published thirty one papers and have taken or applied for twenty patents.

ENGINEERING AND TECHNOLOGY

A. GENERAL.

I. *Historical*:

(a) *Engineering Education*: India has always fostered learning and has had its indigenous crafts from ancient times. The inspiring cultural traditions of South India are still seen in its ancient temples and its temple architecture, as well as in its ancient river and irrigation systems. Engineering, especially Civil Engineering as applied to building of temples, mutts, choultries, bridges, &c., and river control and irrigational schemes can be said to have had its origin even as early as the days of the Chola, Pandya and Pallava Kings or earlier even. Special temple architects called "Stapathis" are still practising the ancient art in some of the Southern Districts. Palm leaf inscriptions of their art are still seen in some of the old manuscripts in the libraries such as the Saraswathi Mahal Library in Tanjore.

These ancient techniques could not, however, serve the needs of changing times and Engineering studies on modern scientific lines had its early origin at Madras, in a school for Surveyors started as early as 1794 by the East India Company. This was perhaps the most ancient Engineering Institution to be started in India on Western lines. It was some time about 1842 that this school was re-organised on more systematic lines. In 1858, it was redesignated as Civil Engineering School and got affiliated to the Madras University which was established then. The Institution moved over to its own buildings (now designated the Old Engineering College buildings) in 1859. In 1880 the Engineering School developed into a Civil Engineering College with a three-year Degree Course in Civil Engineering and a 2½ years' subordinate course. The Degree Course in their present form (the B.E. Degree) with branches in Civil and Mechanical Engineering were introduced in 1894. So, this College has the distinction of starting the Mechanical branch before any other institution in India. In 1912, the course was revised to a 4-year course after Intermediate. In 1920, the College shifted to its present location at Guindy. In 1930, a separate branch was started in Electrical Engineering with again another branch in Telecommunication Engineering in 1945 and Highways in 1946. Graduates from this College have been rendering distinguished service in various branches of Engineering all over India.

The early development of Engineering Education in South India is intimately connected with the development of this Engineering College at Madras. This institution has now grown into a model College of its kind with several branches and post-graduate courses. Particulars of this Institution along with other Engineering & Technical Institution in the Madras State are furnished at the end of this article.

Quite a number of Engineering Institutions were started during the last three decades in the various States comprising the Southern region, such as in Andhra Pradesh, Mysore and Hyderabad and Kerala. The various Universities also started their own departments of Engineering & Technological studies, such as the Universities of Andhra, Annamalai, Mysore, Osmania & Travancore Universities. Several Engineering Colleges were also started by private bodies, such as the P.S.G. & Sons' College at Coimbatore and the Alagappa Chettiar College at Karaikudi and an Engineering College at Madura, recently. A list of these colleges and their year of foundation is given in a separate list.

(b) *Development of Technological Studies*: The institution of technological studies in selected branches of specific interest and applicability to the Southern region, was engaging the attention of the Madras University ever since 1933. It was, however, only in 1944 that the Degree Course, B.Sc. (Tech.), was instituted in the newly opened University College of Technology at Guindy. The origin of this Institution is a fascinating study in itself.

The starting of technological studies was delayed, though it was felt long overdue, due to want of adequate financial provisions for launching a suitable scheme. The question was taken up in earnest in November 1942, when a generous offer of three lakhs of rupees was made by the South India Mill Owners' Association for starting a College of Technology at Coimbatore. An Expert Committee which was constituted by the Madras University, however, felt that such an Institution should be located in Madras. It was a munificent donation of Rupees Five Lakhs made by the late Dr. Alagappa Chettiar and a generous non-recurring grant of Rupees Seven Lakhs with an annual recurring provision of Rs. 85,000 provided by the State Government that made it possible for the Madras University to start a college of technology at Guindy. The University of Madras, in grateful appreciation of Dr. Alagappa Chettiar's donation, resolved to name the College after him.

It is but fair to add that the credit for the wise planning and the development of this College belongs to the Vice-Chancellor, Dr. A. L. Mudaliar, whose continuous devotion, great energy and enterprise have been primarily responsible for the development of technological studies in the Southern region during the past two decades.

The Alagappa Chettiar College of Technology, as this University College is called, started with three branches of studies, i.e., Chemical Engineering, Textile Technology and Leather Technology, giving due recognition to the textile and leather trades in South India, as well as the great potentialities for chemical and allied industries in this region. This institution has been rapidly growing into a vast technological Campus. Several research departments in applied Sciences, such as Physics, Physical Chemistry, Organic and Bio-Chemisty, Geology and Geophysics, which have a large contribution to make for the development of Technological studies, have also been moved over to this Campus since 1952. Details of this institution are included in the lists provided at the end of this article.

There is another institution entirely started by private donations catering to special technological studies, of which special mention must be made. This is the Madras Institute of Technology which was started in 1949, with courses of studies in Automobile Engineering, Electronics, Aeronautical Engineering and Instrument Technology. The institution has been taking Science Graduates and training them in these faculties, giving them its own Diploma after a three-year course.

Technological studies have also been instituted by the Andhra, Annamalai, Osmania and Travancore Universities, since about 1945. Mysore has had the distinction of having fostered one of the foremost research institutions in India, i.e., the Indian Institute of Science at Bangalore. It was started in 1911 as a centre of pure scientific research, but has added within the last 15 years, new departments in Applied Sciences and Technology. Considerable expansion in post-graduate work and research in Engineering and Technological subjects in this institute have taken place during the last ten years and details of these are furnished separately.

(c) *Technical Education in Polytechnical Schools*: The rapid development of our country's industry and resources depends not only on Technologists at the higher educational level, but also on Technicians at lower levels—who may be craftsmen trained in various specialities after a minimum educational standard. This was realised with the birth of independence and there has been a constant effort made to increase the technical and crafts schools. A list of these polytechnics (or technical schools) with the particulars of courses provided by them is given in a Table separately. Most of these schools train the students to a syllabus and pattern which have been finalised for several branches by a Technical Diploma Board set up by the Department of Industries, Government of Madras. A comprehensive picture of the variety and location of Technical institutions at all levels throughout Southern India is given in a map separately.

II. *Practical Training of Technical personnel*:

Practical training in an Industry after the technical education of the student has been prescribed for Technical Graduates of the University. A similar training is also prescribed for Polytechnic students by the Technical Diploma Board. Facilities for such training are being offered by several industries, private firms, and Governmental projects. A list of such firms in South India is given separately.

The Government of India as well as the State Governments have been offering a number of stipends for practical training in various selected industries and projects. More than 75 stipends at graduate level and 100 stipends at diploma level are being offered every year.

III. *Research Schemes on Industrial problems and their scope*:

Various research projects, both of an academic nature and of practical types of interest to industries are being sponsored in the various technological institutes and Universities from Government funds as well as funds from private industries and agencies.

Most of these are sponsored by Government agencies like the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research, the Department of Atomic Energy, etc. Only some of them are now sponsored by private industrial agencies and bodies. Some of the subjects in which research is carried out are listed separately. Interests and financial help for more of such schemes by private industries is bound to develop rapidly in the future, as better liaison is developed between technological research centres and industries. Research schemes of special interest to various branches of Engineering are also being handled by the engineering research laboratories set up by the state engineering departments, such as:

(1) *The Irrigation Research Station at Poondi*: Under the Public Works Department, Madras, where scale models of dams, rivers and irrigation projects are set up and working data obtained for use by the irrigation engineers.

(2) *The Highway Research Station at Guindy* where studies of practical interest to road engineers are being taken up. This institute has just started functioning.

There are three national research laboratories run by the Central Government, situated in the southern region which carry out investigations of special interest to the industries and trade in the respective fields. They are:

(1) *The Central Leather Research Institute at Guindy*: This institute has been carrying out investigational work in the tanning and finishing of leathers as well as in the study of indigenous tanning materials. Work has also been done in the reclamation of waste leather and use of such waste material for making compressed leather boards, and other leather articles.

(2) *The Electro-chemical Research Institute at Karaikudi*: This has been carrying out investigational work of interest to various electro-chemical industries, such as electro-chemical refining, electro-plating, etc.

(3) *The Central Food Technological Institute at Mysore*: Work is being carried out on synthetic foods, vitaminised food preparations and preparation and preservation of various food products.

IV. *Technical Societies and Bodies contributing to the growth of Engineering profession:*

Various technical bodies, such as the Institution of Engineers (India), The Indian Institute of Chemical Engineers, The Electro-Chemical Society of India, The Indian Institute of Metals, The Aeronautical Society of India, and The Institution of Telecommunication Engineers, have branches at various centres in the southern region and by their journals and regional activities help in the fostering and advancing of technical knowledge and "know how" in various specialities.

The Institution of Engineers (India) have their regional headquarters and their own buildings at Madras with an up-to-date library. The institution provides opportunities for young apprentices and practising young engineers to qualify themselves in different branches of engineering.

Some regional bodies, such as the South Indian Steam Users' Association, have their regional activities where in co-operation with industries, they assist the industries in effecting economy in the use of fuel and steam.

V. *Present and Future Trends in Technical Education in Southern Region:*

With the development of the various industries, both large and small, envisaged under the Five-Year Plans, it is expected that there will be a heavy demand of engineers, technologists, and technicians at all levels in the southern region. Both representatives from industries and educational authorities have come close together in the post-independence period of our country and have been carrying out an assessment of the requirements of technical personnel in the various regions. The Regional Office of the All-India Council for Technical education has its own office at Madras and it has been rendering very useful and significant service in the co-ordination and expansion of technical education both at degree and diploma level.

On assessing the development of technical education in the southern region, the following figures were collected by about the end of 1956.

Of the total intake capacity of about 6050 at degree level and 8700 at diploma levels in the engineering institutions all over India, the capacity of the southern region is about 1969 at degree level and 4407 at diploma level as shown below:

State		Intake capacity of all institutions	
		Degree	Diploma
1. Andhra State	..	530	1346
2. Kerala	..	100	355
3. Madras	..	626	1317
4. Mysore	..	713	1389
Total	..	1969	4407

Subject-wise the technical education intake in this region is broadly as follows:

Subjects		Intake capacity	
		Degree	Diploma
1. Civil	..	919	1650
2. Mechanical	..	431	830
3. Electrical	..	436	817
4. Telecommunications	..	20	87
5. Automobile	..		222
6. Aeronautical	..	12	9
7. Sanitary and Public health	..	15	86
8. Mining	..		45
9. Metallurgy	..		13
10. Highway	..	25	
11. Architecture	..	15	25
12. Boilers, instruments, welding, sheet-metal work, etc.	..		124
13. Sculpture, metal work and other art-crafts	..		128
14. Chemical Engineering	..	71	36
15. Chemical Technology (General)	..	16	
16. Pharmaceuticals and fine chemicals	..	27	15
17. Food Technology	..		24
18. Ceramics	..		36
19. Leather Technology	..	15	12
20. Textile Technology	..	30	79
21. Fisheries	..		80
22. Printing	..		109
23. Cinematography and Sound Engineering	..		46

There are also Certificate Courses in different crafts and trades which are rather numerous to list out.

Expansion in many of these subjects, as well as institution of new courses are already under way in many centres.

VI. *Post-Graduate Courses in Engineering and Technology*:

Several post-graduate courses in engineering and technology have recently been started at Madras, Chidambaram (Annamalai University), Coimbatore, Trivandrum and Bangalore (Indian Institute of Science). The subjects covered in the post-graduate courses are:

(1) Soil Mechanics & Foundation Engineering.
(2) Automobile Engineering.
(3) Foundry Engineering.
(4) Electrical Engineering.
(5) Electrical Machine Design.
(6) Electrical Communication Engineering.
(7) Industrial & Production Engineering & Industrial Administration.
(8) Dam Construction, Irrigation Engineering & Hydraulics.
(9) Structural Engineering.
(10) Public Health Engineering.

The development of a Southern Higher Technical Institution envisaged as long ago as 1946 by the Central Government has only recently been taken up. The higher technological Institution for the southern region has been planned to be located at Madras.

The facilities, such as adequate land, water and electricity, and amenities provided by proximity to adjoining University departments of technology and research have influenced the selection of a site very close to "Raj Bhavan", (Government House), Guindy.

The Madras State government has started a colony of small industries near Guindy. A polytechnic institute is also planned here, which will provide training of craftsmen and technicians for different trades who can be absorbed in the small and medium scale industries.

The Madras University as well as the various technical institutions in the Southern Region have always been striving to maintain a good standard, trying to improve the quality rather than the quantity of the output from their institutions. The need has also been felt that there should be some liberal education in addition to the technical studies in the curricula for engineering and technical studies to give the technical young men a broader and better outlook. Subjects such as Economics, Business Management and Human Relations, have been, therefore, duly emphasised in the revised curricula in the various branches of technical studies.

An attempt to co-ordinate the activities of all technical institutions in the Madras State, both at degree and diploma level, has been going on for some time, and it has resulted in the recent formation of a Directorate for Technical Education which will be responsible for technical education both in the colleges and polytechnic schools.

A list has been attached to this article of all colleges and technical schools as listed in 1956 in the Southern Region. A map has also been provided to give at a glance the picture of technical education in the Southern Region.

Research in Engineering and Technology had not been taken up seriously till a few years back, but a number of institutions are taking up research work along with their post-graduate courses. A list of some of these institutions with the research work they have taken up is indicated in a brief way — based upon information which could be gathered recently. It is, however, a matter of general complaint that technical men are not attracted as yet in large numbers to a research career, especially as there is a large and expanding field of employment available to them in private and public sectors which offer more attractive terms. The opportunities for employment of highly specialised engineers for suitable occupations has not yet developed enough to encourage very high specialisation.

There is, however, little doubt that with the increasing realisation of the potentialities and need of applied research in our expanding industries both in engineering and technical fields, and with the increasing numbers of research fellowships and studentships offered by the various Universities, governments and industries, bright young men with an aptitude for research work will be attracted more and more towards a career devoted to research.

B. STATISTICAL DATA ON TECHNICAL INSTITUTIONS AND SUBJECTS

SURVEY OF TECHNICAL INSTITUTIONS IN THE SOUTHERN REGION 1956

List of Engineering, Technological and Architectural Institutions in the Southern Region

	Name of the Institution (1)	Year of foundation (2)	Engineering (3)			Technology (4)		
			P.G.	D.	L.	P.G.	D.	L.
	Andhra Pradesh							
1.	College of Engineering Anantapur	1946	—	x	x	—	—	—
2.	College of Engineering Kakinada	1946	—	x	x	—	—	—
3.	University College of Engineering, Waltair	1955	—	x	—	—	—	—
4.	University College of Engineering, Osmania University, Hyderabad (Dn.)	1929	—	x	—	—	—	—
5. @	J. V. D. College of Science and Technology, Waltair	1933	—	—	—	x	x	—
6.	Department of Chemical Technology Osmania University, Hyderabad (Dn.)	1945	—	—	—	x	x	—
7.	Government Technical College, Hyderabad (Dn.)	1923	—	—	x	—	—	—
8. *	Government College of Fine Arts, Hyderabad (Dn.)	1940	—	—	x	—	—	—
9.	Government Ceramic Institute, Gudur	1954	—	—	—	—	—	x
10.	Andhra polytechnic, Kakinada	1946	—	—	x	—	—	x
11.	Vuyyuru polytechnic, Vuyyuru	1946	—	—	x	—	—	—
12.	Government polytechnic, Vizakhapatnam	1956	—	—	x	—	—	—
13.	Government polytechnic, Warrangal	1955	—	—	x	—	—	—
	Kerala							
14.	College of Engineering, Trivandrum	1939	—	x	—	—	—	—
15.	Maharaja's College, Ernakulam	1944	—	—	—	x	—	—
16.	Maharaja's Technological Institute, Trichur	1947	—	—	x	—	—	—
17.	Institute of Textile Technology, Trivandrum	1938	—	—	—	—	—	x
18.	Government polytechnic, Kalamassery	1951	—	—	—	—	—	x
19.	Alagappanagar polytechnic, Alagappanagar (via) Trichur	1956	—	—	x	—	—	—

	Name of the Institution (1)	Year of foundation (2)	Engineering (3)			Technology (4)		
			P.G.	D.	L.	P.G.	D.	L.
20.	Kerala polytechnic, Kozhikode	1946	—	—	x	—	—	x
	Madras							
21.	College of Engineering, Annamalai University, Annamalainagar	1945	x	x	—	—	x	—
22.	P. S. G. & Sons Charities College of Technology, Coimbatore	1926	x	x	—	—	—	—
23.	Government College of Technology, Coimbatore	1945	—	x	—	—	—	—
24.	Alagappa Chettiar College of Technology, Guindy	1944	—	—	—	x	x	—
25.	College of Engineering, Guindy	1794	x	x	—	—	—	—
26.	Alagappa Chettiar College of Engineering and Technology, Karaikudi	1952	—	x	—	—	—	—
27.	Coimbatore Institute of Technology, Coimbatore	1956	—	x	—	—	—	—
28. @	Department of Pharmaceutics, Madras Medical College, Madras	1939	—	—	—	—	x	x
29.	Madras Institute of Technology, Chromepet, Madras	1949	x	x	—	—	—	—
30.	Madura Engineering College, Madura	1956	—	x	—	—	—	—
31.	Government polytechnic, Coimbatore	1945	—	—	x	—	—	—
32.	C. N. T. Institute, Vepery, Madras-7	1906	—	—	x	—	—	—
33.	Ramakrishna Mission Technical Institute, Madras	1925	—	—	x	—	—	—
34.	Institute of Leather Technology, Madras	1915	—	—	—	—	—	x
35.	Tamilnad polytechnic, Madurai	1946	—	—	x	—	—	—
36.	Central polytechnic, Madras	1916	—	—	x	—	—	x
37.	P. S. G. & Sons Charity Industrial Institute, Coimbatore	1926	—	—	x	—	—	x
38.	Alagappa Polytechnic, Karaikudi	1955	—	—	x	—	—	—
39.	Seshasayee Institute of Technology, Tiruchirapally	1952	—	—	x	—	—	—
40.	Regional School of Printing Technology, Madras (In Central Polytechnic, Madras)	1916	—	—	—	—	—	x

Name of the Institution. (1)	Year of foundation (2)	Engineering (3)			Technology (4)		
		P.G.	D.	L.	P.G.	D.	L.
41. Annamalai polytechnic, Chettinad	1956	—	—	x	—	—	—
Mysore							
42. College of Engineering, Bangalore	1917	—	x	—	—	—	—
43. B. M. S. College of Engineering, Bangalore	1946		x	—	—	—	—
44. B. D. T. College of Engineering, Davanagere	1951		x	—	—	—	—
45. B. V. Bhoomareddi College of Engineering and Technology, Hubli	1948			x	—	—	
46. National Institute of Engineering, Mysore	1946	—	x	x	—	—	—
47. Sri Krishnarajendra Silver Jubilee Technical Institute, Bangalore	1938						
48. Sri Jayachamarajendra Occupational Institute, Bangalore	1943	—	—	x	—		
49. Indian Institute of Science, Bangalore	1911	x	x	—			
50. School of Engineering, Bangalore	1914						
51. Silver Jubilee Technical School, Mysore Iron and Steel Works, Bhadravati	1950	—	—	x	—	—	—
52. Occupational Institute, Chintamani	1950	—	—	x	—	—	—
53. Sm. L. V. Occupational Institute, Hassan	1949	—	—	x	—	—	—
54. D. R. R. Occupational Institute, Davanagere	1949	—	—	x	—	—	—
55. Rayalaseema polytechnic, Bellary	1948	—	—	x	—	—	—
56. Karnataka polytechnic, Mangalore	1946	—	—	x	—	—	—
57. K. H. Kabbur Technical Institute, Dharwar	1956	—	—	x	—	—	—
58. Government polytechnic, Gulburgah	1955	—	—	x	—	—	—
Total No. of Institutions—58.		1	18	33	5	6	12

P. G. Post-Graduate Level. **D. Degree.** **L. Licentiate.**
@ Pharmacy etc.
*** Architecture, Sculpture, Design, etc.**

REGION — SOUTHERN ; SUBJECT — ENGINEERING AND TECHNOLOGY ; STANDARD — POST-GRADUATE — 1956

Name of Institution.	Auto. Engg.		Elec. Commn.		Ele. Chem. Engg.		Chem. Engg.		Chem. Tech.		Pharm. Chem.		Oil Fats. Arom.		Tex. Tech.		Leather Tech.		Sugar.		Ore Dressing.		Foundry Engg.		High Voltage Engg.	
	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT
ANDHRA PRADESH																										
1. J. V. D. College of Science and Technology, Waltair. ..	—	—	—	—	4	1	6	5†	—	2	5	5	—	—	—	—	—	—	1	—	2	2	—	—	—	—
2. Department of Chemical Technology, Osmania University, Hyderabad. ..	—	—	—	—	—	—	—	—	—	1*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MADRAS																										
3. A. C. College of Technology, Guindy. ..	—	—	—	—	—	—	21	31	—	—	—	—	—	—	14	12	3	10	—	—	—	—	—	—	—	—
MYSORE																										
4. Indian Institute of Science, Bangalore. ..	—	3	18	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	6
KERALA																										
5. Maharaja's College, Ernakulam. ..	—	—	—	—	—	—	—	—	—	—	4	4	3	4	—	—	—	—	—	—	—	—	—	—	—	—
Total (5) ..	—	3	18	21	4	1	27	36	—	3	9	9	3	4	14	12	3	10	1	—	2	2	—	3	—	6
	1		1		1		2		2		2		1		1		1		1		1		1		1	

OT Out turn.
IT In take.

† D Sc. Research.
* Ph.D.

REGION — SOUTHERN ; SUBJECT — ENGINEERING ; STANDARD — DEGREE — 1956

Name of Institution. (1)	Civil OT	 IT (2)	Mechanical OT	 IT (3)	Electrical OT	 IT (4)	Tele-Communication. OT	 IT (5)	High-ways OT	 IT (6)	Miscel-laneous. OT	 IT (7)	Remarks. (8)
ANDHRA PRADESH													
1. College of Engineering, Kakinada. ..	44	50	23	30	16	30	—	—	—	—	—	—	Intake break up approx. Students are branched of at the end of the second year only.
2. College of Engineering, Anantapur. ..	26	30	22	24	17	30	—	—	—	—	—	—	-do-
3. University College of Engineering, Waltair. ..	—	50	—	25	—	25	—	—	—	—	—	—	-do-
	(Started recently in 1955. No out turn yet)												
4. University College of Engineering, Hyderabad. ..	76	65+ 40	14	20+ 20	16	15+ 20	—	—	—	—	—	—	-do-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MADRAS							
5. College of Engineering, Annamalai• University, Annamalainagar. ..	42 60	30 26	10 29	— —	— —	— —	-do-
6. Government College of Technology, Coimbatore ..	12 40	23 25	18 25	— —	— —	— —	-do-
7. P. S. G. & Sons' Charities College of Technology, Coimbatore. ..	— *40	53 30	51 30	— —	— —	— —	-do- * First batch in 56-57.
8. A. C. College of Tech., Karaikudi. ..	27 50	17 36	12 30	— —	— —	— —	Intake break up approx.
9. College of Engineering, Guindy. ..	50 50	30 30	40 40	20 20	20 25	— —	-do-
10. Madras Institute of Technology, Chromepet. ..	— —	— —	— —	25 24	— —	11 9 25 25 17 25	Aeronautical Automobile Instrument Technology.
11. Coimbatore Institute of Tech., Coimbatore. ..	— 40	— 30	— 30	— —	— —	— —	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MYSORE							
12. B. M. S. College of Engineering, Bangalore. ..	75 90	104 60	66 30	— —	— —	— —	Intake break up approx.
13. College of Engineering, Bangalore. ..	123 80	74 60	57 40	— —	— —	— —	-do-
14. B. D. T. Engineering College, Davanagere. ..	38 90	— —	— —	— —	— —	— —	-do-
15. National Institute of Engineering, Mysore. ..	78 60	— —	— —	— —	— —	— —	-do-
16. B. V. Bhoomareddy College of Engineering and Technology, Hubli. ..	68 53	— —	— —	— —	— —	— —	-do-
17. Indian Institute of Science, Bangalore. ..	— —	2 6	— —	— —	— —	5 7	Aeronautical.
						— 3	Instrument Technology.
						12 17	Metallurgy.
						1 4	Civil Hydraulics.
						11 9	Power Engg. Elec.
KERALA							
18. College of Engineering, Trivandrum. ..	40 50	20 25	25 25	— —	— —	— —	
Total ..	599 989	412 447	325 399	45 44	20 25	82 99	
	16	14	13	2	1	2	

REGION — SOUTHERN ; SUBJECT — TECHNOLOGY STANDARD — DEGREE — 1956

Name of Institution.	Chem. Engg. and Chem. Tech. OT	Chem. Engg. and Chem. Tech. IT	Chem. Tech. (General) OT	Chem. Tech. (General) IT	Pharmaceutical OT	Pharmaceutical IT	Textiles OT	Textiles IT	Remarks.
ANDHRA PRADESH									
1. J. V. D. College of Science and Technology, Waltair. ..	—	—	—	24 (Sugar & Ele. Cheml. Tech.)	7	11	—	—	
2. Department of Chemical Technology, Hyderabad (Dn.). ..	—	30 (Output in 57 only)	—	—	—	—	—	—	
MADRAS									
3. Annamalai University, Annamalainagar. ..	29	48	—	—	—	—	—	—	
4. Department of Pharm. Medical College, Madras. ..	—	—	—	—	5	15	—	—	
5. Sri Krishnarajendra, Silver Jubilee Tech. Instt., Bangalore. ..	—	—	—	—	—	—	24	20	
6. Indian Institute of Science, Bangalore. ..	8 77	25‡ 23	— —	— —	—	—	—	—	‡ Elecl. Tech. Power Engineering.
	34	126	—	24	12	26	24	20	
Total — 6 ..									
No. of Institutions — 6 ..	3		1		2		1		

REGION — SOUTHERN ; SUBJECT — ENGINEERING

Name of Institution.	Civil		Mech.		Elec.		Elec. & Mech.		Tele-Commn.	
	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT
(1)	(2)		(3)		(4)		(5)		(6)	
ANDHRA PRADESH										
1. College of Engineering, Kakinada.	—	25	—	50	—	25	—	—	—	—
2. College of Engineering, Anantapur.	—	25	—	50	—	25	—	—	—	—
3. Andhra Polytechnic, Kakinada.	65	107	14	30	9	34	—	—	—	31‡ Radio Engg.
4. Vuyyuru Polytechnic.	46	50	12	25	—	25	—	—	—	—
5. Government Polytechnic, Vizakhapatnam.	— newly	50	— started	25	—	25				
6. Government Tech. College, Hyderabad (Dn.). †	—	50	15	30	10	30	*17	190	—	—
7. Government College of Fine Arts. Hyderabad (Dn.).	—	—	—	—	—	—	—	—	—	—
8. Government Polytechnic, Warrangal.	—	40	No output now.				—	—	—	—
MADRAS										
9. P. S. G. & Sons' Charities Industrial Institute, Coimbatore.	—	50	3	25	3	25	—	—	—	—
10. Government Polytechnic, Coimbatore.	—	—	—	—	—	—	—	.—	—	21‡ (No output yet)
11. Central Polytechnic, Madras.	48	128	39	49	37	44	—	—	—	—
12. Tamilnad Polytechnic, Madurai.	10	120	4	55	23	55	—	—	—	—
13. C. N. T. Institute, Vepery, Madras-7	30	75	23	38	33	37	—	—	—	—
14. Ramakrishna Mission Techl. Instt., Madras.	—	—	—	—	—	—	—	—	—	—
15. Alagappa Polytechnic, Karaikudi.	—	‡50	—	30	—	20	(No output yet)			

STANDARD — DIPLOMA — 1956

Auto. (7)		Sanitary. (8)		Mining. (9)		Arch. (10)		Misc. (11)		Unclassified. (12)		Remarks. (13)
OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	
—	—	—	—	—	—	—	—	—	—	—	—	100 IT for all breakup approx. No output yet.
—	—	—	—	—	—	—	—	—	—	—	—	
11	24	—	—	—	—	—	—	—	—	—	—	‡ No output yet.
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
†30	†30	—	—	—	—	—	—	—	—	—	100	† Newly started. Overseer trade courses newly started. No outturn. * Course bifurcated.
—	—	—	—	—	—	11	30	34	113§	—	—	§ Includes sculpture & Commercial Art, Design, etc.
—	—	—	—	—	—	—	—	—	50 (Overseer No output)			
—	—	—	—	—	—	—	—	—	—	—	—	
20	21	—	—	—	18‡ (No output)	—	—	—	—	—	23‡ (Agri. Engg. No output)	30 in each course.
—	—	8	20	—	—	—	—	—	—	—	—	
3	19	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—*	—	—	—	—	—	—	
20	30	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	

(1)	(2)		(3)		(4)		(5)		(6)	
16. Seshasayee Institute, Tiruchirapalli. ..	—	†50	—	30	—	20	(No output yet)			
17. Annamalai Polytechnic, Chettinad. ..	—	50	(No output yet).				(-do-)			
MYSORE										
18. Government Polytechnic, Gulbargh. ..	—	42	—	—	—	—	—	—	—	—
19. Karnataka Polytechnic, Mangalore. ..	16	40	12	20	—	—	—	—	—	—
20. B. V. B. College of Engineering and Techl., Hubli. ..	22	43	7	20	2	20	—	—	—	—
21. K. H. Kabbur Instt., Dharwar. ..	—	60	(No output)				—	—	—	—
22. National Institute of Engineering, Mysore. ..	50	40	—	—	—	—	—	—	—	—
23. S. J. Technical Instt., Bhadravati. ..	—	—	28	34	—	—	—	—	—	—
24. School of Engineering, Bangalore. ..	58	120	30	45	26	45	—	—	—	—
25. S. J. O. Institute, Bangalore. ..	22	43	11	35	30	43	—	—	*13	27
26. Occupational Institute, Chintamani. ..	14	24	—	—	27	30	—	—	—	—
27. D. R. R. Occupational Institute, Davanegre. ..	9	50	14	30	30	50	—	—	—	—
28. Sm. L. V. Occupational Institute, Hassan. ..	9	30	15	31	17	30	—	—	—	—
29. Rayalaseema Polytechnic, Bellary. ..	14	40	—	—	—	—	—	—	—	—
KERALA STATE										
30. Maharaja's Technological Institute, Trichur. ..	29	40	19	20	13	20	—	—	—	—
31. Government Polytechnic, Kalamassery. ..	—	—	—	—	—	—	—	—	—	—
32. Alagappanagar Polytechnic, (Via) Trichur. ..	—	60	(No output yet, started in 56 only)						—	—
33. Kerala Polytechnic, Kozhikode. ..	20	40	4	20	6	20	—	—	—	—
Total — 33. ..	452	1542	250	692	266	623	17	190	13	79
	28		21		20		1		3	

(7)		(8)		(9)		(10)		(11)		(12)		(13)
—	—	—	—	—	—	—	—	—	—	—	—	Out of 77, 15 Civil, Engg. and 27 Agri. Engg.
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
5	15	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	‡50	(Overseer Trade course
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
12	32	3	23	12	25	—	—	‡37	107	—	—	* Includes Radio Engineering. ‡Includes Machine Mech. Engg. Boilers Instrumental Engg. Designs etc. Mine Mech. Welding Sculpture.
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	18	40¶	—	—	¶ Electrical.
23	20	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
94	191	11	73	12	43	11	30	89	260	—	173	
8		3		2		1		3		3		

REGION—SOUTHERN; SUBJECT TECHNOLOGY; STANDARD—DEGREE—1956

Name of Institution. (1)	Chem. Engg. (2)		Pharm. (3)		Food Tech. (4)		Ceramics. (5)		Textile Tech.* (6)		Fisheries & Navgn. (7)		Printing (8)		Cinema & Sound (9)		Leather Tech. (10)		Remarks. (11)
	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	OT	IT	
MADRAS																			
1. P. S. G. & Sons Charities Industrial Institute, Coimbatore. ..	—	—	—	—	—	—	—	—	1	30	—	—	—	—	—	—	—	—	* Textile Manufacture.
2. Department of Pharm. Madras Medical College, Madras. ..	—	—	16	37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
3. Central Polytechnic, Madras. ..	—	—	—	—	—	—	—	—	—	—	7	20	—	—	4	9	—	—	
4. Institute of Leather Technology, Madras. ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	28	Leather goods manufacture.
5. Regional School of Printing Technology. ..	—	—	—	—	—	—	—	—	—	—	—	—	19	32	—	—	—	—	
ANDHRA PRADESH																			
6. Andhra Polytechnic, Kakinada. ..	—	—	—	—	—	—	—	—	—	—	0	20	—	—	—	—	—	—	

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
7. Government Ceramic Institute, Gudur.	..	— —	— —	— —	0 15 (No output)	0 1	— —	— —	— —	— —	Pottery, Refractory, Glass and Enamel.
MYSORE											
8. S. K. S. J. Technological Institute, Bangalore.	..	— —	— —	— —	— —	1 —	— —	— —	— —	— —	
9. Sri Jayachamarajendra Occupational Institute, Bangalore.	..	— —	— —	— —	0 19	— —	— —	5 11 — —	6 20 6 19	— — — —	
KERALA											
10. Government Polytechnic, Kalamassery.	..	— 20	— —	10 6	— —	— —	16 20	— —	— —	— —	
11. Institute of Textile Technology, Travancore.	..	— —	— —	— —	— —	8 24	— —	— —	— —	— —	
12. Kerala Polytechnic, Kozhikode.	..	5 14	— —	3 6	— —	— —	— —	— —	— —	— —	
Total No. of Institutions 12	..	5 34 2	16 37 1	13 12 2	— 34 2	10 54 3	23 60 3	24 43 2	16 48 2	6 28 1	

REGION — SOUTHERN ; SUBJECT — ENGINEERING — 1956

Subject	Post-Graduate			Degree			Diploma		
	No. of Instt.	OT	IT	No. of Instt.	OT	IT	No. of Instt.	OT	IT
Civil (including public health) ..	1	—	—	16	599	989	28	452	1542
Mechanical ..	—	—	—	14	412	447	21	250	692
Electrical ..	1[8]	—	6	13	325	399	20	266	623
Elecl. & Mechl. (combined) ..	—	—	—	—	—	—	1	17	190
Power Engg. (Elecl.) ..	1	—	—	1	1	9	—	—	—
Tele-communication ..	—	—	—	2	45	44	3	13	79
Automobile ..	1	—	3	11	25	25	8	94	191
Sanitary ..	—	—	—	—	—	—	3	11	73
Aeronautical ..	1	—	—	2	16	16	—	—	—
Mining ..	—	—	—	—	—	—	2	12	43
Metallurgy ..	1	—	—	1	12	17	—	—	—
Highway ..	—	—	—	1	20	25	—	—	—
Architecture ..	—	—	—	—	—	—	1	11	30
Instrument Techl. ..	—	—	—	1	17	25	—	—	—
Miscellaneous ..	1[6]	2	2	1[9]	—	3	1[1]	37	107
Unclassified ..	1[2]	16	2	1[10]	1	4	1[3]	34	113
..	1[7]	—	3	—	—	—	3[4]	—	173
	—	—	—	—	—	—	1[5]	18	40
Total ..	4	18	16	18	1472	2003	33	1215	3896

1. Includes machine Mechanical Engineering, Boilers, Instruments, Welding of Engines (Mechl.) Sheet-metalling.
2. Electrical communication.
3. Sculpture Commercial art Design, etc.
4. Includes Overseer trade courses and Agriculture Engineering.
5. Electrical.
6. Ore Dressing Engg.
7. Foundry Engg.
8. High Voltage Engg.
9. Includes Internal Combustion.
10. Civil Hydraulics.

REGION — SOUTHERN ; SUBJECT — TECHNOLOGY — 1956

Subject	Post-Graduate			Degree			Diploma		
	No. of Instt.	OT	IT	No. of Instt.	OT	IT	No. of Instt.	OT	IT
Chemical Engg. and Chemical Tech. ..	3	27	36	3	34	126	2	5	34
Chemical Tech. (General) ..	2	—	3	1	—	24	—	—	—
Pharmaceuticals and Fine Chemicals ..	2	9	9	2	12	26	1	16	37
Oils, Fats and Aromatics ..	1	3	4	—	—	—	—	—	—
Food Technology ..	—	—	—	—	—	—	2	13	12
Sugar ..	1	1	—	—	—	—	—	—	—
Textile Chemistry ..	—	—	—	—	—	—	—	—	—
Ceramics ..	—	—	—	—	—	—	†2	—	34
Glass ..	—	—	—	—	—	—	—	—	—
Leather ..	1	3	10	—	—	—	1	6	28
Textile Technology ..	1	14	12	1	24	20	3	10	54
Fisheries Technology and Navigation ..	—	—	—	—	—	—	3	23	60
Printing ..	—	—	—	—	—	—	2	24	43
Cinematography and Sound Engineering ..	—	—	—	—	—	—	2	16	48
Miscellaneous ..	*1	4	1	—	—	—	—	—	—
Total ..	5	61	75	6	70	196	12	113	350

* Electrical Chemical Technology.

† Includes for Glass also.

REGION — SOUTHERN ; SUBJECT — ENGINEERING AND TECHNOLOGY ; STANDARD — DEGREE, DIPLOMA AND POST-GRADUATE — 1956

Subject		Post-Graduate			Degree			Diploma		
		No. of Instt	OT	IT	No. of Instt.	OT	IT	No. of Instt.	OT	IT
Engineering including Architecture, etc.	..	1	20	16	18	1473	2003	33	1215	3896
Technology includes Pharmaceuticals, etc.	..	5	61	75	6	70	196	12	113	350
Total	..	6	81	91	24	1543	2199	45	1328	4246

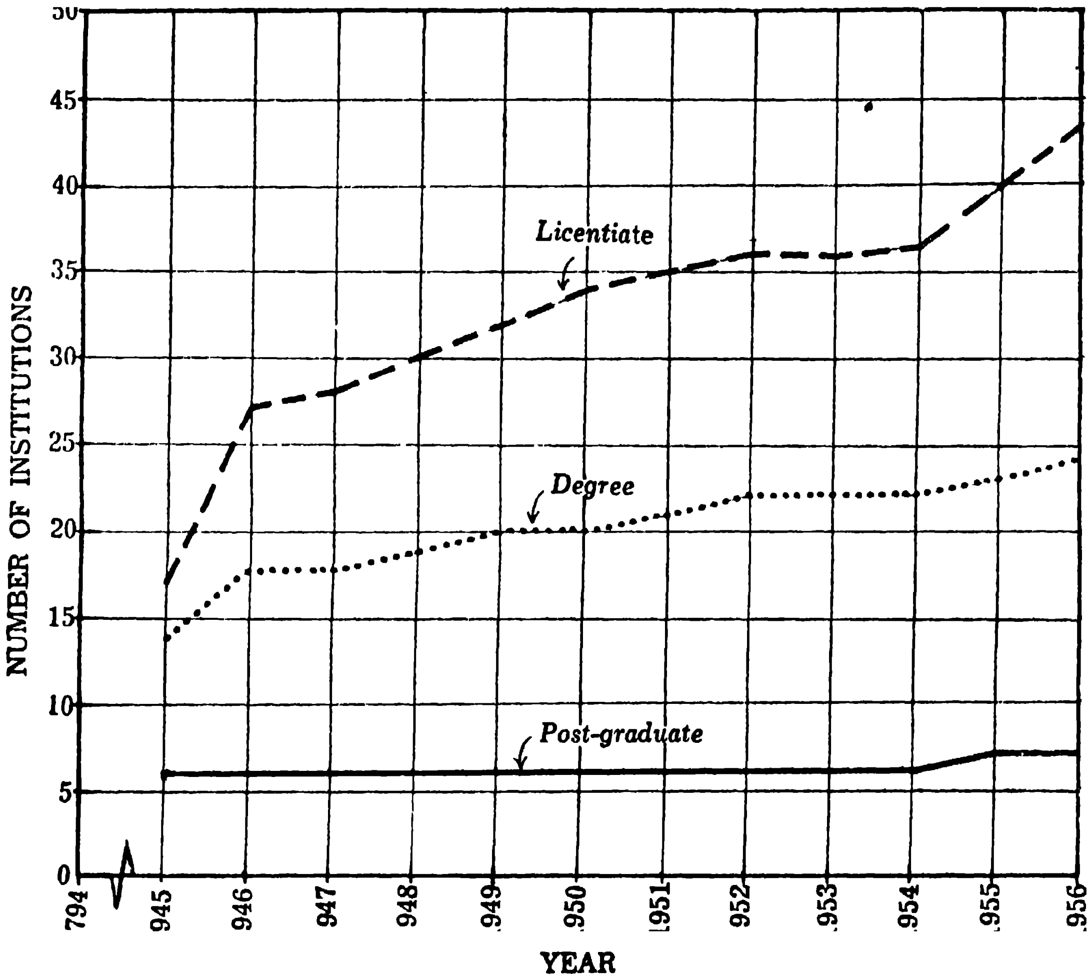
SOME INDUSTRIAL ESTABLISHMENTS IN THE SOUTHERN REGION WHERE STUDENTS GET PRACTICAL TRAINING

(a) PARTICIPANTS IN THE PRACTICAL TRAINING PROGRAMME FOR TECHNICAL GRADUATES

1. Indian Telephone Industries Ltd., Duravaninagar, Bangalore.
2. Hindustan Machine Tools Ltd.. Jalahalli. Bangalore.
3. Bharat Electronics Ltd., Jalahalli, Bangalore.
4. Mysore Iron and Steel Works, Bhadravati.
5. India Pistons Ltd., Huzur Gardens, Madras.
6. Textool Co. Ltd., Coimbatore.
7. The Travancore Rayons Ltd., Rayonapuram, Travancore State.
8. Fertilisers & Chemicals Travancore Ltd., Udyogamandal.
9. P. S. G. & Son's Charities Industrial Institute, Peelamedu, Coimbatore.
10. The Mettur Chemical & Industrial Corporation Ltd., Mettur Dam Railway Station, Salem district.
11. Madura Mills Ltd., Madurai.
12. Indian Aluminium Co., Ltd., Alupuram, Alwaye.
13. Beehive Foundry Engineering Works, Madras.
14. The Buckingham & Carnatic Mills, Ltd., Madras.
15. The Metal Box Co. of India (Private) Ltd., Madras.
16. Binny's Engineering Works Ltd.. Madras.
17. Hindustan Shipyard, Visakapatnam.
18. Ramakrishna Industrials Ltd., Peelamedu.
19. Hindustan Aircraft Ltd.. Bangalore.
20. Simpson & Co., Ltd., Mount Road, Madras.
21. Kirlosker Electric Co., Ltd., Bangalore.
22. The Praga Tools Corporation Ltd.. Secunderabad (Dn.).
23. The Travancore-Cochin Chemicals Ltd., Udyogamandal.
24. Dandayudhapani Foundry Ltd., Coimbatore.
25. The Mysore Chrome Tanning Co., Ltd., Bangalore.
26. The East Asiatic Co. Ltd., Tondiarpet, Madras.
27. Parry & Co., Ltd., Madras.
28. The Nanco Rubber & Plastics Ltd., Coimbatore.
29. The Mysore Chemicals & Fertilisers Ltd., Belagula, Mysore.
30. Sri Rangavilas Mills Ltd., Coimbatore.
31. The Coimbatore Pioneer Mills Ltd., Peelamedu, Coimbatore.
32. Coimbatore Spinning & Weaving Co., Ltd., Coimbatore.

(b) CERTAIN OTHER INDUSTRIES

1. Integral Coach Factory, Madras.
2. Government Soap Factory, Bangalore.
3. Hindustan Machine Tools, Bangalore.
4. Addison Paints & Chemicals Ltd., Madras.
5. T. I Cycles of India Ltd., Madras.
6. Bangalore Woollen & Cotton Mills Ltd., Bangalore.
7. Hindusthan Vanaspathi Manufacturing Co., Ltd., Tiruchirapalli.
8. Government Sandal Oil Factory, Mysore.
9. Mysore Vegetable Oil Products Ltd., Bangalore.
10. Motor Industries Ltd., Bangalore.
11. Government Electric Factory, Bangalore.
12. Government Porcelain Factory, Bangalore.
13. Kerala Soap Works, Kozhikode.
14. Thungabadra Industries Ltd.
15. Mysore Sugar Co., Ltd., Mandya.



Graph showing the Growth of Technical Institutions.

(C) Schemes of Research and Investigations in different Institutions in the Southern Region.

Some investigational and research work carried out in the various colleges and technological institutes are listed below:

I. Madras

(1) *College of Engineering, Guindy*: The college has well equipped laboratories and was the first institution to provide facilities for research. Several students have qualified for the M.Sc. degree in engineering and a few for the Doctor's degree.

The college has done industrial research and was the first to set up a plant for testing producer gas plants for automobiles. Investigations have also been carried out on the use of vegetable oils and charcoal gas as fuels in Diesel engines. Irrigation research has also been carried out on problems connected with the several irrigational schemes in the province. An up-to-date laboratory is available for testing materials and investigations are carried out in this laboratory which are of practical interest to engineering departments and industry. A micro-testing section has been added to this laboratory recently.

The hydraulics laboratory is well equipped and some investigations have been carried out through pervious foundations here.

Investigations on deflections in R. C. structures, have been carried out in the concrete laboratory.

The electrical laboratory is one of the best equipped in the college and investigation on polyphase induction motors, as well as on a type of synchronous motor where A.C. supply is made to both the stator and rotor were carried out here. A high voltage section is also attached to the electrical laboratory where investigations on insulators and insulation materials are carried out.

The telecommunication laboratory, the highways laboratory, and the public health engineering laboratory are also very well equipped for both post-graduate work and research.

(2) *The Alagappa Chettiar College of Technology, Guindy*: This is situated next to the Engineering College at Guindy and has developed a vast campus where both technological work as well as work in applied sciences can be carried out side by side. A well equipped textile section is also available as a separate unit in this campus. The neighbouring Central Leather Research Laboratories and Tanneries provide facilities for training technologists in leather trade. Separate building for housing engineering laboratories and workshops are being built now.

The college trains personnel for the professions Chemical Engineering, Textile Technology and Leather Technology. The college has a very well equipped pilot plant section for chemical engineering instruction and research and some of the investigations carried out in this section are given below:—

1. *Synthetics from Fats and Oils*: A comprehensive review of the production of synthetic detergents from vegetable oil origin was prepared. Fractional crystallizations of commercial stearic acid from acetone and methyl alcohol, acetone and rectified spirit, and benzene and methyl alcohol binary mixtures were attempted with good results (Janardhan, 1950b). Optimum conditions for ammoniation process for converting fatty acids into their corresponding nitriles were investigated (Janardhan, 1950c). The nitriles thus prepared were converted into the corresponding amines

by reduction at copper cathode (Janardhan, 1953a) and the process was awarded a patent (44230 Indian Patent). Various conditions for dehydrating castor oil were tried in the presence of different catalysts like $NaHSO_4$, Silica gel, etc., and under reduced pressure (Kannayya & Janardhan, 1950). Attempts were made to increase the unsaturation of dehydrated castor oil by halogenation and dehalogenation and the properties of the resulting resinous products were studied (Kannayya & Janardhan, 1951).

2. *Analytical Research*: In a programme of development of analytical methods, various new techniques have been reported by the laboratory. The colorimetric method for the determination of copper employing rubeanic acid had been critically examined (Janardhan, 1953). The colorimetric estimation of tin using phosphomolybdic acid has been developed (Subrahmanyan & Janardhan, 1955). A summary of work carried out on estimation of tin by electrodeposition at controlled cathode potential from acid and alkaline solution has been done (Subrahmanyan & Janardhan, 1955). A new and accurate method for estimation of germanium has been developed (Hamsath Ibrahim & Madhavan Nair, 1956). The coulometric technique has been extended to a number of nonaqueous solvents and to mixture of such solvents with water.

3. *South Arcot Lignite Utilization*: Investigations on the nature and properties of South Arcot Lignite included proximate analysis and determination of calorific value, sulphur and nitrogen contents. The low temperature carbonisation assay was performed at different temperatures. The proximate analysis of the chars and the determination of their calorific value were also carried out (Subrahmanyan & Madhavan Nair, 1954). A complete study of the low temperature tar, obtained from the lignite at 600°C, has been made. Montax wax was extracted with solvents at different pressures. Preparation of high quality active carbons from lignite has also been studied under the influence of activating agents such as steam, zinc chloride, phosphoric acid, calcium chloride, etc., at temperatures varying from 500°C to 800°C. The adsorptive properties of the carbons obtained were quantitatively studied on different adsorbents like iodine, oxalic acid, methylene blue, malachite green, etc., and suitability of these carbons has been demonstrated for decolorising molasses, palm ghur and cane jaggery (Jagannadhaswamy & Madhavan Nair, 1955). Aerial oxidation of lignite was done with fixed as well as fluidised beds and the best conditions for the maximum yield of humic acid have been worked out.

4. *Unit Operations and Process Research*: Investigations on the kinetics of absorption of CO_2 by alkalis were completed (Chandrasekhar, 1950). A study for developing a basic correlation between the power required for the transport of slurry was undertaken and design data were obtained (Poonen, 1954). An investigation into the sedimentation of fine particles in a centrifugal field has given interesting results.

A study of the nature of filtration, structure of filter cakes and the role of filter-aids in filtration was made for evaluation of filtration technique (Subba Rau, 1955). An investigation of the vapour liquid equilibria over ternary system involving acetic acid, water and salts has indicated that the vapour-equilibria for acetic acid-water system are highly influenced in the presence of salts (Venkataraman, 1954). The design and fabrication of a direct fired firebrick lined rotary kiln was studied to evaluate the various factors influencing them (Jayaraman, 1949). A design for a cylinder cap for use with leaky gas cylinders was developed (Jayaraman, 1950).

Potentialities of the development of cotton seed oil industry in India were stressed and economics of cotton seed crushing have been discussed (Laddha, 1954). The various ginning processes used in India have also been discussed (Mohanty, 1954). Vegetable oils of commerce have to be refined free from fatty acids before further processing. Investigations were carried out to apply solvent extraction process to effect this separation and to discover suitable solvents to separate the fatty acids for the oils. In this connection, complete equilibrium and phase distribution data were obtained for peanut oil—oleic acid—acetic acid and peanut oil—oleic acid—furfural at 40°C (Venkataraman & Laddha, 1955). In a study of the extraction of glycol from aqueous solution the ternary systems Glycol—n Butyl alcohol—water and Glycol—isobutyl alcohol—water were studied and equilibrium and tie line data have been obtained (Lakshminarasimhan, Gopalan & Laddha, 1956).

The laboratories of the college are at present engaged with the problems of heat transfer in packed beds, extractive distillation techniques, liquid—liquid extraction studies and beneficiation of the naturally occurring ores in South India.

(3) *Madras Institute of Technology (at Chromepet)*:

This institute is very near the Chromepet station, two stations south of Guindy in suburban electric railway, and provides facilities for training and research in the fields of (1) Aeronautical Engineering, (2) Automobile Engineering, (3) Electronics and (4) Instrument Technology.

The following Research and Development Projects are in progress:—

Faculty of Aeronautical Engineering:

1. Design and Development of a two-seater Sailplane, incorporating a mechanism for boundary layer control on the Glider wings with a view to developing a workable unit for application to powered aircraft.

2. Development of methods for structural analysis of aircraft "swept-back" wings.

3. Study of fatigue problems associated with aircraft design and construction.

Faculty of Automobile Engineering:

1. Design and Development of a "multi-purpose two-stroke engine".

2. Development of facilities of the "Two-stroke Engine" Project involving

   (a) Component testing (Metallurgical & Structural).

   (b) Studies on combustion efficiency.

   (c) Studies on heat transfer.

   (d) Studies on scavenging efficiency.

Faculty of Electronics Engineering:

1. Development of a "Milli-micro Second Pulse Generator".

2. Development of a "Pulsive Tube Characteristic Meter" to aid work on item 1 above.

3. Celestial Cosmic Radio Noise Investigation.

4. Development of a small scale "Electronic Computer".

Faculty of Instrument Technology:

1. Development of "Optical Flats". (Optical flats accurate to quarter wave-length have been developed. They can be supplied as fundamentals to industrial units. Work on the development of Lenses to that accuracy is in progress).

2. Design and development and prototype manufacture of Scientific Instruments—Vernier Microscopes, Spectrometers, Che-

mical Balance, pH meters, McLeod gauge, Frequency meter, college type Galvanometer, disc recording unit Geiger Counter, etc.

(4) *The Highways Research Station, Madras*:

This research station recently started by the Highways Department of the Madras State is engaged mainly in research work relating to materials and techniques used in the making of roads.

Some of the recent problems engaging the attention of the institute now are listed below:

1. Use of precast, prestressed concrete slabs and blocks in culverts and small bridges.

2. Use of concrete and mortar hinges in R.C. bridges in place of steel roller-bearings.

3. Studies in wear resistance of road surfaces and temperature stresses in concrete pavements.

(5) *The Central Leather Research Institute, Madras*:

This is one of the national laboratories set up by the Central Government, which is located adjacent to the University Departments of Technology and Applied Sciences at Guindy. It has been rendering valuable assistance to the Madras University in running a degree course in "Leather Technology". It is providing part-time instruction as well as training to the young technologists who take up this course.

Research is also carried out by the Institute which is of very great importance to the Leather Industry. Indian Leather Industry to-day is valued to yield about Rs. 40 crores annually. Some of the contributions made by the Institute are listed below:

1. Improvement of raw hides and skins by elimination of damages caused to them by using impure salts and crude methods in curing them.

2. Manufacture of tannin extracts and other indigenous tanstuffs for the Indian tanner.

3. Improving the existing tanning techniques so as to reduce the period of tanning as well as improve the quality of tanned products.

4. Investigation into finishing of leathers for international markets.

5. Utilisation of leather waste for making leatherboards, and bleaching of coloured hair to get white hair.

The institute has been publishing a number of bulletins and has been constantly endeavouring to improve liaison in the leather trade.

(6) *Irrigation Research Station at Poondi*:

This research station, under the State irrigation department, is just below the dam of the Sathyamurthi reservoir, about 10 miles from Madras, just beyond Tiruvellore.

The research station furnishes a modern approach to irrigation and river flow problems. The problems are studied on small scale hydraulic models. Studies on spillway dams, weirs, chute drops, tunnels and infiltration galleries are made here that furnish valuable data for irrigation engineers.

II. COIMBATORE

Coimbatore, which is fast developing into a textile centre for the Southern Region, has three engineering colleges. Some of the work in progress at the P. S. G. & Sons' College of Engineering & Technology which was the earliest college in this area is indicated hereunder.

P. S. G. & Sons' Charities College of Technology, Peelamedu P.O., Coimbatore.

Report on Research Programmes and Research Fields — dated 2-9-1957: Particular mention may be made of the following research programmes which are conducted under the financial sanction of the Council of Scientific and Industrial Research.

A. HYDRAULICS SECTION:

SCHEME No. 1.

Topic: "Development of mixed axial flow pumps of moderate discharge capacity".

Period of Work: The scheme was started on 2-1-1956 and is in progress.

SCHEME No 2.

Topic.: "Design and Manufacture of Water Reaction Turbines of small capacity".

Period of Work: The scheme has been just started on 2-9-1957.

SCHEME No. 3.

Topic: "Design and Manufacture of Venturimeters & Orificemeters".

Period of Work: The scheme has just been started on 2-9-1957,

B. ELECTRICAL ENGINEERING SECTION :

SCHEME NO. 1.

Topic: "Smooth Variable Speed A.C. Motor & Multispeed A.C. Motor".

Period of Work: The work on the scheme was started on 29-11-1955 and is in progress.

SCHEME NO. 2.

Topic: "Study of Magnetic Saturation in Induction Motors".

Period of Work: Work on the scheme is to be started very soon.

SCHEME NO. 3.

Topic: "Development of Master Frequency Changer".

Period of Work: Work on the scheme is to be started very soon.

III. ANNAMALAI UNIVERSITY, CHIDAMBARAM.

This is a Unitary Residential University which was started by the late Raja Sir Annamalai Chettiar, about 25 years back. It has an Engineering College and a department of technology which have been rendering very useful work. Some of the research work, with papers published recently are indicated below :

Research work and papers published include the following :

I. *Civil Engineering.*

1. Prestressing-stone masonary and concrete, (by Prof. G. S. Ramaswamy).
2. Foundations on black cotton soil, (by Sri J. Krishnamurthi Rao).
3. Soil—Stabilization, (Sri. G. Alexander).
4. Pozzolonic Properties of Neiveli clay, (by Sri. M. Kannan).

II. *Mechanical.*

1. Study of Diesel Engine Design Data, (by Prof. C. Rajaram).
2. Study of Cooling Properties of Neiveli Lignite, (by Sri. B. Sreenivasamurthy).

III. *Electrical.*

1. Study Performance of Electrical Machinery under conditions of Hunting in supply, (by Sri. V. Balasundaram).
2. Harmonies in Mercury ARC Current Converters, (by Sri M. F. Khudrathullah).

IV. COLLEGE OF ENGINEERING, KAKINADA, ANDHRA UNIVERSITY.

This is one of the earliest colleges in this area to cater to engineering studies. Some of the features of study and research are indicated below.

Special features of equipment, etc.—The College has now equipped the High Voltage Laboratory with 1.4 Million Volt impulse generator with Transient recorder, one meter sphere gap, an Electrostatic Voltmeter, and a Cascade transformer of 500 K.V. rating for High Voltage testing.

Research and Publications.—A paper has been published on "A critical comparison of MKS and Rationalised MKS Systems with other Systems of Units with special reference to the teaching of Mathematics, Science and Engineering in Technical Institutions in India", by Prof. V. V. L. Rao.

Some Practical Investigations.—"Deflection of a Structure under a falling load—(a general approach to include all types of stress conditions)." By Sri L. Gopalakrishnamurthy.

V. THE INDIAN INSTITUTE OF SCIENCE, BANGALORE

This premier research institute has started several research departments devoted to Engineering and Technology in the course of the last 15 years. A brief account of the same is herewith given:

(a) *Department of Aeronautical Engineering*:

This Department was started in 1943 with the two-fold object of training Aeronautical Engineers and of conducting research in the Aeronautical Sciences. On account of its bearing on Civil and Military Aviation, the Government of India has been taking keen interest in the development of the Department and made substantial capital grants in 1951 for the construction of new wind tunnels and for other equipment. The Department has six wind tunnels of various types and is working in close liaison with the Hindustan

Aircraft Factory. Most of the aerodynamic tests for the aircraft industry are being carried out in this Department. Besides these wind tunnels, the Department possesses a well-equipped structures laboratory, in which the stress-analysis of aircraft structural elements can be made.

Research work is carried out in this Department in the following fields:

(*a*) Fluid mechanics with special reference to Turbulence and boundary layers.
(b) Subsonic and Supersonic flow.
(c) Wind Tunnel techniques and design (Subsonic and Supersonic)

1. *Internal Combustion Engineering*: (This department was started in 1945). Research work has been carried out in the following fields:
   (*a*) Low pressure fuel injection in Diesel Engines
   (*b*) U Type two-stroke Diesel Engine
   (c) Utilisation of heavy fuels and vegetable oils as fuels for H.S.D. Engines
   (*d*) Utilisation of alcohol in single and multi-cylinder engines
2. *Metallurgy*: (This department was started in 1948). Research work has been carried out in:
   (a) Electro-metallurgy and Electro-deposition
   (b) Beneficiation of Low Grade Ores
   (c) Power Metallurgy and Foundry Work
3. *Power Engineering* — This has four sections and the fields in which research work is carried out in them are indicated below:

Electrical Engineering:

(*a*) Power System Design, Power Transmission and Relaying
(*b*) Industrial Applications — Electrical Machines and Apparatus

Mechanical Engineering:

(a) Gas Temperature Measurements
(b) Combustion studies
(c) Mechanics of Materials

Civil and Hydraulic Engineering:

(a) Cavitation and high velocity flow

(b) Exprimental Stress Analysis

(c) Concrete Technology including Reinforced and Prestressed Concrete

(d) Engineering properties of soils under dynamic loads

High Voltage Engineering:

(a) Study of travelling waves.

(b) Insulation problems at E.H.V.

(c) Study of high current surges

4. *Electrical Communication Engineering*: (This was constituted as a separate department in 1947). Research is carried out in:

(a) Radio Engineering, including Ultra-Short and Microwave Technique

(b) Electro-acoustics

(c) Analogue computers

5. *Chemical Technology and Chemical Engineering*: (This was constituted as a separate department in 1951). Research has been carried out in:

Fuel Technology:

(a) Total gasification of low grade coals by fluidization method

(b) Investigation in Fischer-Tropsch Catalysis and reaction fundamentals

(c) Oxo-synthesis under high pressure

Ore-treatment Investigation:

(a) Application of fluidization method on different ores

(b) Application of phase-exchange principle for demineralization of graphite and coal

Isotope Separation Investigation:

(a) Enrichment of heavy water from "Bitterns"

(b) Enrichment of U^{235} and other active agents by adsorption

(c) Separation of B^{10} by thermal diffusion method,

VI. HYDERABAD

(1) *Department of Chemical Technology, Osmania University, Hyderabad (Dn.)* :

The present department of Chemical Technology of Osmania University originated in 1943 as a subsidiary section of the chemistry department. Later it was reconstituted as a separate department and since 1951, the department designated as a Department of Chemical Technology, has included in it subjects like Chemical Engineering and Fuel Technology.

Selection of special subjects are offered both for higher study and research such as (1) Oil Technology, (2) Ceramic Technology and (3) Chemical Engineering including Fuels.

The problems of research which the department has been handling so far have been mainly related to the utilisation of the raw materials of the region in the various local industries. Among the problems that have been handled a few are mentioned below :

(1) Refining, hydrolysis, oxidation and polymerisation of vegetable oils and fats. (2) Utilisation of safflower oil for the surface coating industries. (3) Studies in the mineral constituents of clays. (4) Studies on ceramic materials and titania glass.

(2) *Regional Research Laboratory, Hyderabad* :

These laboratories, which were originally designated as the Central laboratories for scientific and industrial research and run by the Hyderabad State, came under the management of the Government of India after integration of the State with the Indian Union.

New buildings to house the laboratories were opened in 1954, and the Council of Scientific and Industrial Research took over the management of the laboratory since 1956. Since then it has been endeavouring to promote research and investigations aimed at helping various regional industries.

The laboratories afford facilities for (1) analytical work (2) bio-chemical and entomological work (3) chemical engineering and pilot plant investigations (4) investigations of local coals, ores, and clays and (5) processing of palmarosa, gingergrass oil, and cottonseed oil. There is a well-equipped workshop where pilot scale equipment for various research schemes can be fabricated.

GEOLOGY AND GEOGRAPHY •

A summary is given below of teaching and research in Geology and Geography in South Indian Universities in so far as information has been furnished in response to appeals sent to the several Universities. The summary is given in alphabetical order.

GEOLOGY

Andhra University:

The Andhra University consists of a Professor, 2 Readers, 5 Lecturers, and 5 Demonstrators. The post-doctoral work consists of (1) spectrochemical studies in trace elements in mineral deposits, (2) optical and x-ray study of ferro-magnesian minerals, (3) problems of marine geology with particular reference to sedimentation patterns and (4) studies on manganese ore deposits of Visakhapatnam and Srikakulam Districts. Research for the D.Sc. Degree comprises (1) ore microscopic studies on the mineralised rocks of Kolar Gold Fields, (2) studies on physical behaviour of rocks, (3) optical behaviour of pyroxenes in Charnockite-Khondolite interaction rocks, (4) study of clay minerals by Differential Thermal analysis and x-ray studies, (5) Tectonics, structure and geomorphology of the eastern parts of the Cuddapah basin and (6) problems in field geology, igneous petrology, metamorphism and petrochemistry, sedimentary petrology and nuclear geology. Under the auspices of the Council of Scientific & Industrial Research, the following schemes are investigated: (1) Nuclear Geology with particular reference to age determination of South Indian Rocks (2) spectrochemical determination of Rb-Sr ratio in minerals and (3) some aspects of oceanography under the Atomic Energy Commission; three officers determine the black sand concentrates along the east coast with special reference to their economic importance.

Financial resources of the University Department of Geology are: (1) Recurring grant of Rs. 14,000 from the University (2) special research grants per individual teacher from the University (3) U.G.C. grants of about 2·3 lakhs since 1951 (4) equipment grant of Rs. 5,000 from the Council of Scientific & Industrial Research, and 4 Scientific Assistants (5) salary of 3 Field Officers from the

Atomic Energy Commission and (6) Private sponsored schemes for manganese ore beneficiation, salaries of 3 to 4 Research Assistants.

The Department turns out M.Sc. (Pure) Geology average 8 per year, total (since 1945) about 120. M.Sc. (Applied) Geology 8 per year, (since 1954) about 30. D.Sc. 6 from the Department and 3 foreign.

The research of the department has been in Oceanography, Nuclear Geology, and other aspects of Geology. Pioneer work in the study of the ocean bottom sediments yielded data regarding the pattern of sedimentation, sea level oscillations in Pleistocene and carbonate cycle in marine deposits; coastal evolution studies have yielded data on marine transgressions due to man-made and natural causes. Nuclear Geology studies have resulted in the dating of different orogenic cycles and in bringing out the role of magmas and mineralisers in radioactive mineral enrichment. Several hundreds of rocks have been studied for their alpha- and beta- activity, also sea floor sediments, spectrochemical studies have revealed the importance of trace elements in mineralisation. Optical studies of minerals from interaction zones have brought to light new groups of pyroxenes. X-ray study of garnets have resulted in the design of new charts for obtaining the composition of garnets. Sedimentary petrological methods have enabled correlation of the coastal sedimentaries. Petrofabric studies have been correlated to tectonics. Studies of the Cuddapah basin have revealed the nature of the uplift of the basin.

Over 100 publications in various scientific journals such as Proc. Ind. Acd. Sci., Nat. Inst. Sci., Geol. Min. Met. Soc., Ind. Geog. Rev., Economic Geology (U.S.A.), Amer. Jour. of Sci. (U.S.A.), Amer. Mineralogist, Journ. of Sedimentary Petrology, Pan Indian Ocean Science Congress, Proc. Int. Union of Geophysics and Geodesy, International Geological Congress etc. Other important activities are: State sponsored schemes for mineral investigation by prospecting and detailed geological survey with senior students and staff; Geological mapping by research scholars under the supervision of research Directors has been completed for over 1000 sq. miles in Andhra Pradesh.

Karnataka University:

The post-graduate Department of Geology was started in the year 1954. This department was started to undertake research in geomorphology alongside with the other branches of Geology. This is the only department in Northern Karnatak that provides post-graduate tuition in Geology. The research work in the beginning was hence directed towards geomorphological problems, which is borne out by the papers contributed to the Indian Science Congress etc. The first batch of 5 students were admitted to M.Sc. (papers). Two more students were also admitted to M.Sc. (Research). As a result of this the research work was directed towards geological and petrological problems as well.

The staff consists of (1) Dr. M. S. Sadasiviah, M.Sc. (Mys.), D.I.C., Ph.D. (London), F.G.S., Professor and Head of the Department of Geology and (2) Sri N. W. Gokhale, M.Sc., (B.H.U.), Lecturer in Geology. The post-graduate output (1956) is five students (M.Sc. Degree by papers) and one by Research. Special schemes of research are (1) Investigation of the beach sands along the coast from Gokarn to Mangalore (2) Regional Geological Survey of north Karnataka (Mysore). The financial resources of the department are none except from the University Grants Commission. The items of research carried out by the students of the department are: (1) Water Table in Bombay Karnatak (2) Characteristic feature of Drainage around Dharwar (3) Petrology and Geomorphology of the Deccan trap near Kolhapur (4) A note on the geology of Vernoli Hills (5) Recurrence of quartzite band near Karwar (6) Soils and ground water in Bombay Karnatak (7) Windgaps and watergaps in Dharwar (8) Granite-porphyry occurrence near Dharwar (9) A note on Dhumwad sandstone (10) Granite-Gneiss occurring around Ankola.

Madras University:

Geology is taught in the Madras University in two constituent colleges and the Research Department of the University of Madras. The Presidency College, Madras, existing for over 60 years, coaches students for the B.Sc. (Honours) and B.Sc. Degrees. They also offer research degrees up to the M.Sc. and Ph.D. standards. The Department consists of Prof. Paul G. Dowie, M.A.L.T., M.Sc. (Chicago), F.G.S., Chief Professor and Head of the Department, 4 Assistant Professors and 2 Demonstrators. The normal strength of the Department in a year is 36 B.Sc. (Honours) students, 40 B.Sc. (Pass) students, and about 100 students offering Geology as subsidiary for the B.Sc. Degree. The College turns out in a year about 12 B.Sc. (Honours Graduates), 20 B.Scs., and M.Sc. or Ph.D.

The Alagappa College, Karaikudi, trains students for the B.Sc. Degree. It consists of a Professor, an Assistant Professor, a Lecturer and 2 Demonstrators. Their strength is about 40 a year and an equal number for subsidiary Geology.

The Department of study and research, University of Madras, was founded in the year 1952. It consists of a Professor and a Research Assistant. The Department prepares students for the M.Sc. Degree by Examination, M.Sc. Degree by Research and the Ph.D. Degree. It has a total strength in a year of about 15 students of all the above categories. Since 1952, 2 students have obtained the M.Sc. Degree by Research, 12 M.Sc. Degree by Examination, and one Ph.D. Degree. The research of the Department consists in regional geological studies of the Madras State mainly in the branches of Mineralogy and Petrology. All the modern methods of research carried on rocks, minerals and ores—Optical, Chemical and Tectonic—are applied to the various regional collections and the results have been published mainly in the Journal of the University—The Madras University Journal. A résumé of these papers has appeared in the Centenary Volume of the Madras University Journal.

Mysore University:

The Geology Department of Central College, Bangalore was started in the year 1898, and consequently, it is one of the oldest of the Departments teaching Geology in South India. It was started with the idea of recruiting Officers for the Mysore Geological Department which had come into existence a few years back under the guidance of R. B. Foote. Many students who took their degree in Geology from this Department have served the Mysore Geological Department.

Till the year 1917 it was affiliated to the Madras University, and when the Mysore University was started, it naturally became the leading Department teaching Geology in the University. In the early days, officers of the Mysore Geological Department were appointed as Professors E. W. Weatheral and V. S. Sambashiva Iyer were the earliest officers who were put in charge of the Department.

During the year 1920, P. Sampath Iyengar, M.A., who was then the Deputy Director of Geology was appointed as Professor of Geology, and his dynamic personality and enthusiasm was responsible for the rapid progress in the Department. In the year

1927 he was appointed as Director of Geology in Mysore in addition to his being the Professor of Geology in Central College. During the years 1927 to 1932 he was able to bring the two institutions into close contact and this spirit of mutual cooperation and goodwill have been maintained ever since. During his Professorship, the Department grew in all directions and came to be recognised as the foremost Institution in India for both Geoloigcal instruction and Research. It was during this period that several rapid strides were made both in Petrological and Palaeontological sections. The museum was expanded considerably and lot of equipment for advanced research work was provided and a great impetus was given to original investigations. P. Sampath Iyengar retired from service in 1932.

Professor L. Rama Rao succeeded him and he held the office for over two decades from 1932 to 1953 except for a short period of 3 years when he was the Principal of the Intermediate College, Bangalore. During his long association with the Department he continued the traditions laid down by Professor Sampath Iyengar and others.

During this period Geology became very popular and students taking this subject increased considerably. At this time the courses of study were reorganised by the University and intermediate colleges were established in several district headquarters and Geology was allowed as one of the optional subjects. The newly introduced two year Intermediate course was followed up by either a two year B.Sc. Degree or a specialised three year Honours course. Several of the Honours students have distinguished themselves and are now holding responsible positions in the Geological Survey of India, Indian Bureau of Mines, Atomic Energy Commission and Assam Oil Company. Professor L. Rama Rao who gave a great impetus to the development of original investigations in Palaeontological Problems also trained a large number of young men in this branch of research. His work on the Micropalaeontology of the South Indian Cretaceous has become a classical work.

It was again during this period that Dr. Pichamuthu conducted elaborate investigations on the Petrological side and published a large number of papers particularly on the Dharwars of Mysore. He was Professor of Geology between 1943 and 1946 during which period he not only continued his work but also added additional equipment to the Department. Subsequently he left the University and became the Director of Geology in Mysore.

Dr. P. R. Jagapathi Naidu who was an Assistant Professor in this University for a long period took great interest in the development of Crystallography and mineralogy. A large number of students were trained by him in this branch of Geology up to the Master's Degree. Later on, after his return from Switzerland he joined the newly opened Department of Geology and Geo-Physics of the Madras University.

Professor S. R. Narayana Rao who was in this department for over 20 years has published a large number of papers on the Foraminifera of the Tertiary rocks of North West India. At present he is the Head of the Department of Geology in Lucknow University and also the Director of Uttar Pradesh Geological Survey. Similarly Professor K. Sripada Rao was in this Department for over 15 years and contributed several papers on the Micropalaeontology of the Inter-trap beds near Rajamundry.

In recent years the Department of Geology in Central College has expanded further and the number of students has almost doubled itself. There are on an average about 20 students in each of the Honours classes and about 12 students in the M.Sc. class. Since the introduction of the Ph.D. in this university in 1954, three students, two of whom are on the staff of this department, have obtained the doctorate degree. Six members of the staff have gone abroad to the U.K., U.S.A., and Australia to qualify themselves for higher degrees. At present a number of staff members have registered themselves for the doctorate degree. There are three Government of India Senior Research Scholarship holders working in the Department. There is also a Mysore University Fellowship holder who has just started his work.

The University Grants Commission has been very generous and has given a liberal grant of Rs. 30,000 in 1955-56 to equip a Chemical Laboratory for doing rock and mineral analyses. From the liberal grants given by the Commission and our own University, the Department has been able to buy several advanced equipment for Research, such as Polarograph, Phase contrast microscope, Ore microscope and Refractometers.

At present the Department is in charge of M. R. Srinivasa Rao and he is assisted by a team of experienced and qualified teaching staff. The tradition of the Department is being continued in good spirit and scores of young men are going out of this Department and are finding employment in responsible positions and the Department is proud of them.

At present the following important problems are being studied in this laboratory by the staff and also the various Research scholars.

(1) Structure and mineralogy of several granitic rocks from Mysore.

(2) Study of the structure of the Schist belt in Tumkur district.

(3) Mineralogy of the river sands of Mysore.

Important contributions made by the Department for the advancement of Geology

PETROLOGY

P. Sampath Iyengar.	Has contributed several papers mostly on classification correlation and Petrology of the Dharwar rocks.
C. S. Pichamuthu.	Series of papers on sedimentary origin, structure and Petrology of Dharwar rocks with particular reference to Quartzites, Conglomerates and Iron Ore rocks of Mysore.
M. R. Srinivasa Rao.	Petrography and Metamorphism of Cuddapah rocks and Structure of granitic rocks from Mysore.

MINERALOGY

P. R. Jagapathi Naidu.	Mineralogy of the Charnockite rocks.
M. G. Chakrapani Naidu.	Study of Amphiboles and Pyroxenes of Mysore.
C. Gundu Rao.	Study of heavy minerals from Dharwars, Cuddapahs and Cretaceous rocks of South India.

PALAEONTOLOGY AND STRATIGRAPHY

L. Rama Rao.	Stratigraphy and Micropalaeontology of the Cretaceous rocks of South India.
S. R. Narayana Rao.	Study of the Foraminifera from the Tertiary rocks of Western India.
K. Sripada Rao.	Micropalaeontology of the Inter-Trap beds near Rajamundry.
S. Sambe Gowda.	Micropalaeontological studies from the Cretaceous rocks of South India.

Osmania University :

The special schemes of research are:—(1) Studies in the elastic behaviour of rocks, specially under high pressure (2) petrofabric investigations in the quartzites and marbles of the Pakhals of Yellandu area. The turnout is about 9 M.Scs. per annum. There has been one Ph.D. They organise seminars and essays. Capt. S. M. Ahmeduddin, the Head of the Department, has published two papers on the age of Pakhals and Sullivais of Warangal District and the properties of precious stones. Dr. S. Balakrishna has published 2 papers in Attenuation of Sound in Rocks and a Peep into the Depths of the Interior of the Earth.

GEOGRAPHY

In South India (Madras-Kerala-Mysore-Andhra States) there are 8 Universities and only in four Universities (Karnataka, Madras, Mysore and Osmania) facilities are available for graduate and post-graduate teaching and research in Geography.

Details of colleges offering Geography, strength of students and staff and yearly out-put in the four universities are given in the Table below (Table appended as Appendix I, on page 126).

The Karnataka College, Dharwar and the Arts College, Osmania University, Hyderabad are the only colleges in their respective areas offering geography independently at the graduate and the post-graduate levels. In Mysore, there is at present only Post-graduate research, and a two year M.A. course in Geography is under active consideration by the University of Mysore. Maharajah's College, Mysore is the only institution equipped fully for post-graduate teaching and research.

Of the 13 constituent and 60 affiliated colleges of the University of Madras, only in three colleges (Presidency, and Queen Mary's Colleges—Madras and Government Arts College—Coimbatore) Geography is taught at the graduate level, while the Honours and post-graduate classes started in 1948 and 1949 respectively are conducted on an inter-collegiate co-operative basis with the Queen Mary's College, the Presidency College and the Department of Geography, University, as the participating units. The entire work of teaching the Honours and Post-graduate students is done in the University Department by one Professor and one Reader assisted by the teachers of the cooperating colleges.

The three-year degree courses in Geography have been started in July 1957 both in the Queen Mary's College (Madras) and the Government Arts College, Coimbatore, and the Presidency College, Madras, will be starting next year. The new post-graduate classes (M.A. and M.Sc.) will be started in July 1958 on a co-operation basis with the same participating colleges. In the new set-up, provision is made to teach special branches of geography like geomorphology, photo-gravimetry, Industrial Geography and Geography of Population & Settlement.

Research in geography in the Indian Universities has been and is being determined by the conditions of staff, quantum of teaching work, and other routine duties. The Geography Departments of the University of Madras and the Queen Mary's College, Madras, are fully equipped to conduct advanced geographical research. The main research work of the Department of Geography, University of Madras, besides lecture work, has been on intensive and topical lines. As a part of the departmental programme of research both the Professor and the Reader are conducting research on the different aspects of Economic and Regional geography of India with special reference to selected regions (Andhra & Kerala) in South India. Intensive field work in land-use is being carried out in typical localities. Some of the staff-members of the participating colleges are conducting research in the field of urban-geography. Two research students worked in the Department and one was awarded the M.Litt. Degree for his thesis on "Some Aspects of The Regional Geography of Tamilnad" while the other worked for one year on the Agricultural Geography of South India and then proceeded to Oxford for higher studies and obtained the B.Litt. Degree of the Oxford University. Each final Honours and Post-graduate student submits a dissertation on a selected topic and a report on the geographic survey of a selected village. Several surveys of typical villages in the vicinity of Madras were conducted and the results are awaiting publication, finance being the chief bottle-neck.

It is appropriate to make a reference here to the Indian Geographical Society and the Indian Geographical Journal, a quarterly, started in 1926, thanks to the pioneering efforts of that versatile worker, the late Sri N. Subramanyam. The Society through its publication has played no small part in the development and diffusion of geographic thought in India and more particularly in

South India. The Indian Geographical Journal is subscribed for by most of the Indian and foreign Universities.

The Karnataka College at Dharwar concentrates on Cartography especially with reference to land survey and morphological studies and the cartographic laboratory of the college is considered to be the best equipped one. The staff members of the College are engaged in research on the different aspects of the Regional Geography of Mysore State. Valuable work is being done by some of the workers on selected regions of Karnataka on the geomorphological land-use and urban aspects.

In the Maharajah's College at Mysore, the Professor of Geography and his associates are working on land-use population and industries of the Mysore State and the results of their studies have been published in different geographical journals. One of the staff members has submitted a thesis on the Industrial Geography of the Old Mysore State.

The staff members of the Geography Department of Osmania University are also engaged in research on the different aspects of regional geography of the Andhra State.

The geography departments in all these four Universities are now closely associated with the Pilot Project in Regional Survey initiated by the Indian Statistical Institute on behalf of the Planning Commission. Dr. A. T. A. Learmouth of Liverpool University is the Consultant and Dr. George Kuriyan, Professor of Geography, University of Madras, is in charge of the Project for the macro-region of South India.

APPENDIX I

Name of University.	No. of Colleges offering graduate (G) Post graduate (P.G.) Courses.	Total Strength of Department.	Average yearly output of graduates (G) and Post-graduates (P.G.) Average for last 3 years.	No of Staff Members.
Geography Department.				
1. Presidency College.	3	56 (B.A. + B.Sc.).	25 G.	3
2. Queen Mary's College.		40 (B.A. + B.Sc.- 13 (B.A. (Hons.)). 12 (B.Sc. (Hons.)).	8 Hons. 2 P.G. + 14 G.	6
3. Govt. Arts College, Coimbatore.		15 (B.A.).	8 G.	4
Madras University, Geography Department.	Presidency College and Queen Mary's College co-operate with the University in conducting classes at the University Department.	45 to 50 (Honours and Post-graduate).	11 (Honours and P.G. Students).	(University Geography Deptt) 2 + (Presidency) 3 + (Queen Mary's) 5 + (University Chemical Engineering) 1=11.
Geography Department, Karnataka University. Karnatāka College.	1	35 (B.A. + B.Sc.) 3 (P.G.-M.A., M.Sc., and Ph. D.).	15 — 20 3	• 4
Geography Department, University of Mysore. Maharaja's College.	1	60 (B.A.). 1 (P.G.)-(Ph.D.).	25 —	4

MATHEMATICS

DEVELOPMENT OF MATHEMATICS IN SOUTH INDIA

Mathematics has enjoyed considerable popularity in South India since the days when the University started graduate courses. And progressively the students of the subject have extended their domain of study in the subject to more and more modern developments. Starting from the single University of Madras, there have now sprung up several Universities in this region. This report gives an indication of the progress and the present status of mathematical research in this area; the report, for obvious reasons, is more complete regarding the Madras University than regarding the other ones.

Andhra University, Waltair:

Since its very inception this University has been building up a reputation for its organisation of research in various branches. In the Professorial Chair of Mathematics have been the late Dr. T. Vijayaraghavan, and Dr. V. Ramaswamy, both interested in the theory of functions, and old students from Madras. The chair of Mathematical Physics has been occupied by Dr. A. Narasinga Rao, a Geometer, and Dr. S. Meenakshisundaram, who has done distinguished work in the theory of non-linear partial differential equations and Eigenfunction expansions. Both these Professors also are D.Sc.'s from Madras. University and Government of India scholarships are available for research workers and the University has a decent Mathematics library.

The Annamalai University, Annamalainagar:

Many are the Mathematicians of South India who have been associated with this nicely situated unitary University. Dr. A. Narasinga Rao was Professor for seventeen years from 1929, and built up a school of geometrical studies. Dr. T. Vijayaraghavan was also Professor for a year in 1929, Sri G. V. Krishnaswamy Iyengar succeeded Prof. Narasinga Rao, and since 1950 Dr. V. Ganapathy Iyer has been occupying the Professorial chair. The late Dr. S. S. Pillai, Dr. B. Ramamurthy (now in Central Service), Dr. K. Rangaswamy (now Professor of Statistics in the same University)), Dr. M. Venkataraman (now in the Madras University), Dr. V. Seetharaman (now in Madurai Thyagarajar College), Dr. K. G. Ramanathan (now in the Tata Institute at Bombay) and Dr. P. Kesava Menon (now in the Cipher Bureau) have all been at one time or other been on the Mathematics staff of this University.

An up-to-date Library and scholarships from the University and Central Government are available for students in the Mathematics Department. The main subjects of work in recent years have been studies on the space of Integral functions, summability methods, theory of functions and theory of numbers.

The Karnatak University, Dharwar:

The affiliated Colleges are conducting the post-graduate courses. There is as yet no research department in Mathematics in the University.

The Madras University, Madras:

As the oldest University in this part of India, practically all the older generations of Mathematicians have come from this University. The affiliated Colleges have also played a great role in the development of Mathematical studies in this University. From the six Colleges affiliated for the Honours degree and the M.A. degree in Mathematics, namely, The Madras Christian College, The Presidency College, the Pachaiyappa's College, The Loyola College, The St. Joseph's College (Tiruchy), and the Vivekananda College, many bright young men have come out to become serious students of Mathematics, and to occupy high positions in life as Professors or otherwise.

Among Mathematicians associated with the Madras Christian College mention may be made of Prof. Ross, in the early days, and of Sri C. T. Rajagopal (now in the Ramanujam Institute), Dr. P. Kesava Menon, and Prof. Kibble. Some of the younger lecturers in the College have been doing research besides their teaching work, like Lakshminarasimhan and Mrs. Rani Baliah. Prof. Kibble has been closely associated with the organisation and conduct of the Inter-Collegiate lectures for the Honours classes and has also taken classes for the M.Sc. course.

The Presidency College has had a long list of Mathematicians associated with it. Among its staff may be mentioned Professors E. B. Powell, F. S. Evans, J. B. Bilderbeck, P. Ranganatha Mudaliar, G. H. Stuart, E. M. Middlemast, R. Littlehails, K. Ananda

Rao, P. V. Seshu Iyer, S. R. U. Savoor, T. Suryanarayana, G. A. Srinivasan, P. B. Patnaik and P. V. Abdur Rahiman.

During nearly thirty years Professor K. Ananda Rao inspired and started on their mathematical career many who attained mathematical eminence later. Noteworthy among those who came under the influence of the Professor were Dr. T. Vijayaraghavan, Dr. S. S. Pillai, Dr. V. Ganapathy Iyer, Dr. S. Meenakshisundaram, Sri C. T. Rajagopal, Dr. V. Ramaswamy and Dr. K. Chandrasekharan; the Professor has also done important work on convergence and summability, on the elliptic Theta function, and the Riemann Zeta function.

Professor P. B. Patnaik introduced Statistics as a branch of study in the Honours in the Presidency College and also guided the work of some research students in Statistics. After the creation of a Chief Professorship in Mathematics scholarships have been available for students to do research in the department. Dr. Patnaik was the first to occupy the chair of Chief Professor.

Professor P. V. Abdur Rahiman, the present Chief Professor, has been specialising in applied mathematics; after taking his doctorate from the Manchester University he has been guiding students in Fluid Mechanics; such topics as subsonic flow of gases, boundary layer theory, cascade aerofoil theory with particular reference to compressibility effects and Conical field in supersonic flow are engaging the attention of the research workers of this department. Scholarships are available from the Central and State Governments.

Members from the staff of the Pachaiyappa's College have worked as research students in the University department; Sri Vasudevan and Sri A. Ramanathan worked for some time like this. The latter was working on the nature of minimal bicompact and maximal Hausdorff spaces.

The St. Joseph's College and the Vivekananda College have been mainly concerned in the organisation of the Honours course, and they have held the reputation of producing record performances by candidates in the examinations.

The Loyola College has been playing an important role in the development of research in the University since the time that Fr. C. Racine took up the Professorship in Mathematics. He has been mainly responsible for organising and conducting regularly a seminar where interested teachers and research workers study and discuss modern developments in many branches of the subject. He has also been long associated with the teaching of the M.Sc. classes run by the University. Many of the students of the College have taken up research in the University Department or at the Tata Institute at Bombay. Among staff members may be mentioned Dr. K. G. Ramanathan who is now at the Tata Institute, and Sri V. Krishnamurthy, who took his M.Sc. by research in the University and is getting ready a doctoral thesis on the theory of partial differential equations of the elliptic type.

Professor Racine, besides his active participation in the seminars where a variety of topics ranging over Modern algebra, topology, homology and homotopy theories, algebraic geometry etc., have been studied, has also brought out books for the use of Honours students in modern lines on Potential theory, Analysis and Modern Algebra.

Even before the University opened a research department in Mathematics it gave special scholarships to two highly talented students for their studies in England; to Srinivasa Ramanujan, who drew the attention of the world to mathematical potentialities in our country by his extraordinary intuition and grasp of the theory of numbers and to R. Vaidyanathaswamy, who was to mould the future department of Mathematics to a place of eminence among centres of research in India.

The story and the achievements of Ramanujan are too well-known to require any elaboration in this brief account. It may be mentioned in passing that with the co-operation of the Tata Institute the papers of Ramanujan are appearing in print.

An idea of the wide range of interests and the grasp of mathematics characteristic of Dr. Vaidyanathaswamy may be got from perusing the volume of his 'Collected Papers' that the University is just publishing. After a brilliant career in Cambridge and St. Andrew's, Dr. Vaidyanathaswamy returned to India with a Ph.D. and a D.Sc., to take charge of the newly formed department of Mathematics in the University in 1927. His mastery in the subject, untiring zeal, and enthusiasm inspired many students who came to the department during the twenty five years that the Professor served the University.

During the first years the interest of Dr. Vaidyanathaswamy was in Geometry and theory of invariants. Later he worked on a theory of multiplicative arithmetic functions, on topics in group theory, on the study of partially ordered sets and lattices, on the theories of ordinals and cardinals, on Symbolic Logic, on mathematical background to Physics and on set-topology. He published many papers on all these fields and many a student of his started his work from a paper he published. The Professor used to give courses of lectures regularly to research students on various modern developments on these topics. These lectures were of considerable help to students to orient themselves properly in new fields of study.

When the University instituted the M.Sc. courses in certain Sciences, among them Mathematics, to be run by the University itself, the Professor framed syllabi including modern algebra, topology, Quantum mechanics, theory of probability, group representations etc. Two syllabi on these topics were adopted alternately during the first four years. Since the staff consisted now of the Professor and the newly appointed lecturer Dr. Venkataraman, only one syllabus could be offered at a time, and even this involved the need to have Professors from other Colleges to come and lecture on particular topics. Professor Kibble lectured on the theory of Probability and Professor Racine lectured on aspects of modern algebra. The course provided students aspiring to do research the opportunity to gain further knowledge in fundamental fields of study before taking up research, and it also helped the department in finding suitable students to be trained for research. This M.Sc. course, with a third syllabus, is continuing; it will cease when a new two-year M.Sc. run on inter-collegiate lines is introduced in the next year.

Before the Ph.D. Degree was instituted in the University many students took their M.Sc. by research and a certain number of D.Sc.'s were also awarded. After the Ph.D. was made available, and particularly when a M.Sc. by examination was also organised, all students naturally submitted theses for the Ph.D. degree only.

The M.Sc. by thesis was awarded to many students, among whom may be mentioned Dr. T. Venkatarayudu (now in the Andhra University), Miss S. Pankajam (now in the Queen Mary's College, Madras), Dr. P. Kesava Menon (now in the Cipher Bureau), Sri V. Krishnamurthy (now in Loyola College), Dr. K. Chandrasekharan (now at the Tata Institute), Dr. V. S. Krishnan (now in the Madras University), Dr. K. G. Ramanathan (now in the Tata Institute), Dr. M. V. Subba Rao (now at the Venkateswara University), Sri S. Suryanarayanamurthy, Miss Martin Thomas and Miss S. Padmavalli (now in the United States).

The Ph.D.'s of this University in Mathematics are: Dr. K. Chandrasekharan, Dr. C. S. Venkataraman (now in the Kerala Varma College, Trichur), Dr. Mrs. Suseela (now in the British Council at Madras), Dr. Miss N. Padma (now in the Annamalai University), Dr. V. K. Balachandran (now in the Indian Statistical Institute, Calcutta), Dr. M. V. Subba Rao and Dr. S. Swaminathan (who has just left for further work at the University of Paris).

The D.Sc.'s of the University are (the late) Dr. S. S. Pillai, Dr. B. Ramamurthy (now in the Central Service), Dr. A. Narasinga Rao, Dr. V. Ganapathy Iyer (now in the Annamalai University), Dr. S. Meenakshisundaram (now at the Andhra University) and Dr. P. Kesava Menon.

Professor Vaidyanathaswamy published for the use of the M.Sc. students and others also a 'Treatise on Set-Topology', wherein the order properties and their significance in topology are specially treated.

When in 1952 Professor Vaidyanathaswamy retired from the service of the University, he was succeeded by Dr. V. S. Krishnan, who had been a student in the Department before, and who had just returned after taking a D.Sc. from the University of Paris for his work on the structure of partially ordered algebras. The general pattern of work set by Professor Vaidyanathaswamy has been followed after his retirement also. Besides running the M.Sc. course with a new syllabus wherein modern algebra, lattice theory, topology and some notions of representations for these structures are introduced, Dr. Krishnan and Dr. Venkataraman have been giving courses of lectures for the research students on a variety of topics of current interest; such courses lasting each for two months or a term have been given on topics such as: dimension theory, spaces with écart, convergence properties of general spaces, compactness, paracompactness and completeness for general uniform spaces, general theory of abstract algebras, structure theory for composite structures like topological groups or ordered groups, algebraic topology including combinatorial methods and modern theories of Homology and Homotopy, algebraic geometry, projective geometry, function spaces and spectral theory in Hilbert space, etc, The generous grants that the Centenary of the University brought from the Central and State Governments have resulted in the establishment of a permanent chair for Mathematics among other subjects. Dr. V. S. Krishnan who was Reader till then was promoted to the Professorship from July 1957; Dr. Venkataraman, was also promoted to a rotating Readership from 1956. There are plans for having more staff in the Department. The University and the Government of India offer scholarships for promising students to pursue research, and the University library is well-equipped particularly in the matter of all the important periodicals and journals from most countries in Europe and the U.S.A. The staff and most of the students are sufficiently conversant with French and German to fully utilise the material available in these journals.

The Ramanujam Institute of Mathematics founded by Dr. Alagappa Chettiar with Dr. T. Vijayaraghavan as the first Director has been also functioning as a centre of research in Mathematics in Madras during the past seven years. Students have been working here also with scholarships from the National Institute of Sciences and the Ramanujan Institute on topics in function theory, on summability processes, on Tauberian theorems, etc. Sri C. T. Rajagopal who also joined the staff of the Institute in 1951 took charge as Director when Dr. Vijayaraghavan passed away in 1955. From May 1957 the Institute has come under the management of the Madras University. The library of the Indian Mathematical Society is managed by the Institute; so the presence of the Institute now in the Senate House has increased the possibilities for research in this University and has provided further library facilities for students also. Dr. V. K. Balachandran, Miss K. Padmavally, Sri M. R. Parameswaran and Sri M. S. Ramanujan have done good work as students in the Institute.

The Mysore University

The centre of mathematical research in this University has been the Mathematics Department of the Central College at Bangalore. The first Presidents of the Indian Mathematical Society like V. Ramaswamy Iyer and M. T. Narayaniyengar were Professors in this College. In more recent times Prof. B. S. Madhava Rao, Prof. C. N. Srinivasaiyengar, Professor Venkatachaliyengar and others have been active in research work. Quantum mechanics and the theory of elementary particles, modern algebra, group theory and topology, Geometry, fluid mechanics, and topological groups and algebras have been some of the topics in which work has been done. Four or five students have obtained doctorates, and some scholarships are available for research students.

The Osmania University, Hyderabad:

The University runs classes for the M.A. and M.Sc. degrees in Mathematics. The late Prof. R. Krishnamurthy was interested in studies in Indian Astronomy, particularly in finding evidences regarding precession of equinoxes in ancient Indian treatises on Astronomy like the Suryasiddhanta.

The Travancore University, Trivandrum:

This is a young University which is in the process of reorganisation into a Kerala University. Mathematics has been taught at the M.Sc. level. The Statistics department has been conducting research under the guidance of Prof. U. S. Nair.

The Sri Venkateswara University, Tirupati:

This, the youngest University in the South, has started with a well-organised Mathematics department with Professor R. Vaidyanathaswamy as the Head. Dr. M. V. Subba Rao as Reader and a number of younger mathematicians are also in the Department. Some of these younger lecturers are engaged in research also, for a new M. Phil. degree. The University is proposing to run a post-Honours M.Sc. degree wherein Modern algebra and Higher Arithmetic would be included.

MEDICAL AND VETERINARY SCIENCES

MADRAS MEDICAL COLLEGE

The Madras Medical College was opened as a Medical School on 1-7-1835. The object of opening the Medical School was to render the Medical subordinates more efficient in the performance of their professional duties and to give them a more systematic course of study and training under capable officers than was possible by arrangements then existing. The teaching staff then consisted of 4 Officers, two British Officers, one Superintendent, one Assistant Superintendent and two Assistants. The course was for two years and the curriculum of studies consisted of Anatomy, Materia Medica, Medicine and Surgery. Private students were first admitted in 1838 and they obtained along with Government students a free education. Subsequently, three additional Professorships were sanctioned for (1) Anatomy and Physiology, (2) Midwifery and Ophthalmology and (3) Chemistry. When this staff was sanctioned, the duration of medical course which was originally intended for two years was extended to 3 years.

In 1850 the Medical School consisted of 3 courses (1) Private and stipendiary students who had a 5-year course, (2) Apprentices qualifying for Apothecary grade after a four-year course and (3) Medical pupils qualifying for second grade Dresser of the Medical department with a three-year course. In the same year the institution was given the higher designation of College and from 1st October of that year the institution was named as the "Madras Medical College".

In 1863 the college was affiliated to the University of Madras and the Degrees, etc. for successful candidates were conferred by the University. In 1864 the Government sanctioned extensive alterations to the buildings and this was executed and completed by 1867. In the same year, the Government of India sanctioned the augmentation of the staff of the college to 8 major and 5 minor Professorships.

In 1875 for the first time lady students were admitted to the Medical College and it may be mentioned that this was possible at a time when no other Medical College in India admitted lady students and even in Great Britain the admission of lady students into any of the Medical Colleges was a very controversial subject. In the same year the institution of L.M. & S. degree was sanctioned by the Government.

The Hospital Assistants' Course which was hitherto conducted in this College was moved to the Royapuram Medical School in 1882. In 1895, the Sanitary Inspectors course was started in this College. In 1907, owing to the increase in the admission of students and introduction of new curriculum in the Medical studies, the Government sanctioned the construction of the Hygiene and Physiology Laboratories at a cost of 1 lakh and 75 thousand rupees. In 1914, a course leading to B.S.Sc. degree was first instituted and with the opening of these classes, the Hygiene department grew in importance and utility. During the period of the First World War—1914-1918, little progress could be made in the development of this institution. However, on the recommendation of the Inspectorate of the General Medical Council, the Government had to undertake elaborate programmes in the construction of the Medical College and attached teaching hospitals and for the reorganisation of the Medical staff. The University regulations with regard to Medical studies were also considerably modified and as a result of that the L.M. & S. degree was abolished in the year 1925. By 1935, the construction of a combined block for a Pathology Institute for the Medical College and administrative block for the General Hospital which was sanctioned by the Government in October, 1929 was completed. This led to better facilities for work in these departments.

Concurrent with the development of the College, the affiliated clinical institutions were also enlarged and remodelled. After remodelling of the General Hospital, etc., the total staff of the College increased to 118 consisting of 27 Professors and Additional Professors, 8 Lecturers, 58 Tutors, Assistant Professors and Assistant Lecturers and 25 Demonstrators. In July, 1939 the B.Sc. Pharmacy degree course was instituted in this college and from 1950 this course was converted into B. Pharmacy. On the recommendation of the University Commission that inspected the College in 1940, the Government sanctioned the construction of a separate Hygiene block at a cost of Rs. 5 lakhs and for this amount a two storeyed building was constructed and occupied recently. In 1952 the department of Venereology in this College was upgraded as an All India Post-graduate training centre and as a result of it, the Diploma in Venereology course affiliated to

Madras University was instituted in this College. In the same year, the Government Hospital for Women and Children, Madras was upgraded as an Institution of All India Post-Graduate Centre and thereby the number of students admitted to M.D. (Midwifery) and D.G.O. Courses was increased.

In July, 1953 a course leading to the award of B.D.S. degree by Madras University was started in this College. In 1957 the department of Pediatrics was upgraded as an All India Post-graduate training centre and as a result of this the D.C.H. course affiliated to the Madras University has been instituted in this College.

In view of the revised curriculum of studies introduced by the Madras University, students who pass pre-university examinations are admitted to Pre-Professional Course leading to the M.B.B.S., B. Pharmacy and B.D.S. Degree courses. In view of this, Pre-Professional Course was instituted in this College from July, 1957 and consequently the Departments of English, Statistics, Physics and Biology came into force.

A list of post-graduate degree and diploma courses and under-graduate degree and diploma courses conducted in this College is given below:

Post-graduate degree :

1. Doctor of Medicine :—
   - M. D. Branch I—General Medicine.
   - M. D. Branch II—Obstetrics & Gynaecology.
   - M. D. Branch III-A—Pathology (Main) and Bacteriology (Subsidiary).
   - M. D. Branch III-B—Bacteriology (Main) and Pathology (Subsidiary).
2. Master of Surgery :—
   - M. S. Branch I—General Surgery.
   - M. S. Branch II—Ophthalmology.
   - M. S. Branch II—Otto-Rhino-Laryngology.
3. Master of Science—M.Sc. (Medical) :—
   - (a) Anatomy
   - (b) Physiology
   - (c) Pharmacology
   - (d) Biochemistry
   - (e) Bacteriology

4. B.S.Sc. (Bachelor of Sanitary Science)

Post-graduate Diplomas:

1. Diploma in Tuberculosis, Government & University.
2. Diploma in Gynaecology and Obstetrics.
3. Diploma in Otto-Rhino-Laryngology.
4. Diploma in Ophthalmology.
5. Diploma in Radiology.
6. Diploma in Clinical Laboratory Science.
7. Diploma in Maternity and Child Welfare.
8. Diploma Licentiate in Public Health.
9. Diploma in Venereology.
10. Diploma in Child Health.

Undergraduate courses:

1. M.B.B.S.
2. B.D.S.
3. B. Pharmacy.

Other courses:

1. Sanitary Inspector's course.
2. Diploma in Pharmacy course.
3. Certified Radiological Assistant Course.
4. Dark Room Assistants Course.
5. Short training courses for Medical and Non-Medical personnel in the upgraded V. D. Department.

STANLEY MEDICAL COLLEGE, MADRAS

The Madras Government, in April 1938, closed down the Lady Willingdon Medical School and in view of the persistent demand of the Licentiates in the profession, the D.M. & S. diploma, then being awarded, was abolished and the status of the Stanley Medical School was raised to that of a College. The inauguration of the College was performed on 2nd July 1938 by the late Hon'ble Dr. T. S. S. Rajan, the then Minister for Public Health. Admission to the D.M. & S. course was, therefore, discontinued with effect from the above official year and the College was affiliated to the University of Madras. 72 students were admitted to the Pre-Registration Class of whom 12 were military students and 60 civil students inclusive of women students.

The Government of Madras approved the recommendations of the University Commission and the Special Committee for the formation of a Central Institute of Anatomy, Physiology, Bio-Chemistry and Organic Chemistry at the Madras Medical College, until the new buildings for these departments at this College could be got ready. The students of this College were, therefore, undergoing the courses of studies in the above subjects at the Central Institute at Madras Medical College, along with the students of the Madras Medical College.

The new buildings to accommodate the Anatomy and Physiology departments were completed in July 1950 at this College at a cost of Rs. 9·5 lakhs. Fresh admissions to the I M.B.B.S. class of the Stanley Medical College, were simultaneously increased to 100 from 72. Ten Licentiates were also admitted for Condensed M.B.B.S. course. The new building to accommodate the Anatomy and Physiology departments was officially opened by the late Dr. T. S. S. Rajan, the then Minister for Public Health, on 7th September 1950. The Central Institute of Anatomy, Physiology, Bio-Chemistry and Organic Chemistry at the Madras Medical College was consequently bifurcated and these departments were accommodated at the Stanley Medical College buildings itself. With this event, the Stanley Medical College, Madras, became a full-fledged Medical College with facilities for the training of medical students in all the subjects of the Medical curriculum.

The Anatomy department of the Stanley Medical College was upgraded as part of the Scheme for the Upgrading of the existing Medical Institutions for Post-graduate teaching and research. It was formally declared open by the Hon'ble Srimathi Rajkumari Amrit Kaur, the then Minister for Health, Government of India, on the 24th October 1952. The Institute of Anatomy, as it is now named, is an All India Institute for Post-Graduate teaching and Research work in Anatomy. Students from all over India are admitted annually to this Institute of Anatomy for prosecuting higher studies in M.Sc. and Ph.D. courses. Considerable amount of research is being carried out in this Institute both by the post-graduate students and by the members of the Staff.

Consequent on the discontinuance of the condensed M.B.B.S. course by the University of Madras and the conversion of those seats into an equivalent number of seats in the I year M.B.B.S., annual admissions to the College were increased to 110 from 1953-54.

The Stanley Medical College is admitting students for the degree of M.B.B.S., M.D. (Branches I & II), M.S. (Branch I), D.G.O. and M.Sc. and Ph.D. in Anatomy of the Madras University. Besides these, Sanitary Inspector's Certificate Examination course is also being conducted by this College.

THE MADRAS VETERINARY COLLEGE

After the inauguration of the Civil Veterinary Service as a separate department of Government of Madras in 1892, there came the need for establishing a Veterinary institution for imparting instructions in Veterinary Science to train up candidates who could administer to the veterinary needs of the province. The Government accordingly started the Madras Veterinary School which was subsequently designated as the College in 1903, with a strength of 20 students in a rented building in Vepery adjoining the Veterinary hospital run by the S.P.C.A. The course was spread over a period of three years and the minimum qualification for admission was a pass in Matriculation examination. The Government Diploma of G.M.V.C. was awarded to the candidates after the successful completion of the course. The staff of the school consisted of a part-time Principal, an Assistant Principal and three Lecturers. Very soon the post of the Principal was made full-time and permanent buildings were constructed for the college, hospital and hostel.

On the basis of the recommendation of Royal Commission on Agriculture and with a view to raising the standard of the course, the curriculum of studies was revised in 1931. The notable change was the introduction of the 'Ox' as the standard type as against the horse in the past, in the study of Anatomy. Thus this institution was the first to turn over to the study of Anatomy of the ox as the standard type.

The year 1936 is an important landmark in the history of the college, rather in the history of Veterinary education in India, since in that year the college was affiliated to the University of Madras for imparting instructions leading to the Degree of Bachelor of Veterinary Science (B.V.Sc.). Though this was the fourth Veterinary institution to be started in this country, Madras Veterinary College became the first to offer a degree course and now all the 14 Veterinary Colleges in India following her lead are affiliated to the respective Universities. The minimum qualification for the admission for the degree course was a pass in Intermediate examination with Chemistry or Natural Science as one of the optional subjects. The course of study was of three years and one term duration. The Diploma and the Degree courses were run concurrently. Consequent on the transfer of the Livestock section from the Agriculure Department to the Veterinary Department in 1938, the durations of the Degree and Diploma courses were extended to five and 4 years respectively, completely remodelling the curricula and syllabi, giving particular stress to the study of Animal Husbandry in detail. The Diploma and Degree courses were still run concurrently.

In 1946, the duration of the Degree course was curtailed to four years and one term on the recommendation of the Indian Council of Agricultural Research, with a view to have uniform curricula of studies in all the Veterinary institutions in the country. The teaching of Animal husbandry was given a prominent place and the course was aimed at providing a sound knowledge—both theoretical and practical—in all the branches of Animal Husbandry and Veterinary Science. The Diploma course was abolished.

Madras led the way in another aspect also. For the first time in Veterinary education in India, lady candidates were admitted in 1948 to the Degree course of study.

During this period further extensions to the hospital, college and hostel were made from time to time. The different departments have been equipped adequately for teaching and research. The hospital is provided with an up-to-date surgery, x-ray and actinotherapy apparatuses, etc. Different breeds of breeding bulls, a few milch cows, a poultry unit and an artificial insemination centre, are also stationed in the college. A three-storied building for the college and additional hostel buildings are now under construction to meet the acute shortage of accommodation. The college is provided with an up-to-date library.

The admission to the college has been increased considerably and at present the intake is 120 students per year. Besides students from all over the country, this institution attracts candidates from the Philippines, Thailand, Malaya, Burma, Ceylon, Iraq, etc. The Government of India have selected this institution as a training centre for the foreign scholars under the Colombo Plan and the General Cultural Relationship Scholarship Scheme. The staff of the college has expanded to such a proportion that at present there are 10 Professors, 10 Lecturers, 3 Research Officers and more than 35 Assistant Lecturers and 6 Demonstrators to man the 16 Departments of the College. The Regional Sterility Officer is attached to the College. An Artist-cum-Photographer, Physical Director and a Librarian also form part of the staff of the College. Many of the staff possess post-graduate qualifications either taken in India or abroad.

From its inception, the college besides teaching has bestowed its attention on research and investigation on animal diseases. The following are some of the important problems of research carried out by the staff of this College.

1. Anatomical studies of Ox.
2. Bovine lymphangitis.
3. Leptospirosis in dogs.
4. Nasal schistosomiasis.
5. Rhinosporidiosis.
6. Cercarial fauna.
7. Description of a number of helminths.
8. Artificial insemination and semen preservation.

Much earlier to the creation of the Serum Institute this college manufactured the biological products against some of the dreadful contagious and infectious diseases of livestock.

Post-graduate research: After its affiliation to the University, this college again gave a lead in the field of higher Veterinary and Animal Husbandry Education. It was the first Veterinary College in the country to afford facilities for both teachers and research students for conducting investigations leading to the award of M.Sc., Ph.D. and D.Sc. Degrees of the Madras University. So far 13 M.Sc. and 3 Ph.D. Degrees have been awarded in the Faculty of Veterinary Science of this University. Besides the post-graduate work undertaken by the staff and research students, scholars under the Government of India, Education Ministry's Scheme as well as those getting University Studentships are pursuing research problems. The following are some of the important subjects of research carried out recently.

1. Contagious Caprine Pleuro-pneumonia.
2. Studies on Cercarial fauna in city of Madras.
3. Anatomical studies of the fowl.
4. Studies on surra.
5. Studies on semen stains and the morphology and development of the spermatozoa of farm animals.

6. Investigation on the occurrence, distribution and properties of vegetable and animal tissue phosphatases.
7. Genetical studies in cattle and poultry.
8. Study of the elephant foetus.
9. Haematological studies in cattle and sheep.
10. Designing of Physiological apparatuses.
11. Transthoracic Oesophagatomy for removal of Spirocerca nests.
12. Life-history of *Oesophagostomum radiatum.*
13. Life-history of *Moniezia.*
14. Bionomics and control of aquatic snails.
15. Life-history and epidemiology of *Ascaris vitulorum.*
16. Worm-burden and host-specifity of *Haemonchus.*
17. Cooperiasis in buffalo calves.
18. Amphistome life-histories and Cercariae.
19. *Tetrameres* infection in fowls.
20. Bionomics of oribatid mites.
21. Prevention of helminthic infection in ruminants by routine treatments.
22. Survey of Amphistome infection in ruminants.

The recognition by the University of Madras of additional subjects for post-graduate work in the college now, has made nine subjects available for such studies. This opportunity is being utilised by the staff and students in considerable numbers. The problems under investigation at present are:

1. Pharmacological studies on certain indigenous drugs and chemicals.
2. Animal nutritional studies.
3. Studies on silage.
4. Blood transfusion in dogs.
5. Haematological studies in fowls.
6. Utilisation of carcases and prepartion of blood meal.
7. Bioclimatic studies.
8. Studies on Poultry husbandry.
9. Avian leucosis complex.
10. Ascitis in dogs.
11. Hepatitis contagiosa canis.
12. Studies on *Trypanosoma evansi.*
13. Parasitic survey in domestic animals and poultry.
14. Treatment of Nasal schistosomiasis.
15. Studies on Drosophila.

16. Survey of Tetrameres and other helminthic infections in poultry.
17. Cerebro-spinal nematodiasis.
18. Dracunculosis in animals.
19. Fascioliasis in ruminents.
20. Host-parasite relationship in helminthic infection.
21. Helminthic parasites in carnivores.

Out of those who have pursued research problems in the college so far, four have been awarded the Degree of M.Sc., and one the Degree of Ph.D. Another staff member was awarded the Degree of D.Sc. in the Faculty of Chemistry of the Andhra University. The Fellowship of the Royal College of Veterinary Surgeons—United Kingdom—has been awarded to a member of the staff, who happens to be the only Indian to receive this post-graduate Diploma. One has submitted his thesis for Ph.D. while another has completed his studies for M.Sc. Two members of the staff are working for Ph.D. and eight are pursuing their studies for M.Sc.

In addition to the teaching departments, there are three research units meant exclusively for research. The Helminthology Research department has elucidated the life history of *Oesophagostomum Columbianum.* Bionomics and control of fresh water snails, life histories of *Ascaris vitulorum* and *Moniezia* and other helminthic problems are under study. Bovine mastitis and Animal nutrition research sections are engaged in their respective problems.

Post-graduate education: From 1922 the college conducts as and when necessary post-graduate Refresher course for the graduates in service with a view to keep them abreast of modern developments in Veterinary Science and Animal Husbandry.

A post-graduate Diploma course in Veterinary Parasitology extending over a period of one academic year is conducted from 1956. As this is the only advanced course in Veterinary Parasitology in the country, candidates from many States seek admission to it and every year six students undergo this course.

The Indo-American Agricultural Mission has selected this institution as one of the four centres in the country for post-graduate research and education. Accordingly, plans have been sent to upgrade the college for facilitating the introduction of

M.V.Sc. course and for the increased intake of candidates for post-graduate research.

In addition to teaching and research, the outstanding work to the credit of this college was the compilation of a 'Monograph on the Anatomy of Ox' which is under publication. The organization of helminthology museum which contains hundreds of parasites collected from animals and birds from India as well as from other countries and the Animal Pathology and Anatomy museums are notable features of this institution.

Outstanding Alumni: Some of the members of the staff who were the alumni of this college have earned international reputation in their respective branches of study. Sri M. A. N. Rao, the outstanding Parasitologist, Sri V. Krishnamoorthy Aiyar, the eminent Bacteriologist, and Sri H. N. C. Iyengar, a well known Anatomist, are notable among them. Many of the alumni of the college employed outside this State either in this country or in the eastern countries have played an appreciable role in the development of animal husbandry and have secured a name and fame.

Grants and Aids: The Helminthology Research section was started in 1939 with a 50% grant from the Indian Council of Agricultural Research. The aid continued till 1952. The compilation of the monograph on Ox Anatomy was done with the full aid of the Indian Council of Agricultural Research. The Post-graduate Diploma course in Veterinary Parasitology is being run with a 50% grant from the Indian Council of Agricultural Research. The Bovine Mastitis scheme and the scheme for the investigation of the diseases of reproductive system and sterility in cattle are also aided by the Indian Council of Agricultural Research. During 1956 some equipments were received under the Wheat Loan Agreement (grant) from America. Equipments and books worth about Rs. 56,000 are expected shortly under the Technical Cooperation Mission Aid of the U.S.A. Another indent for additional equipments and books and periodicals is under scrutiny. A few of the staff are being sent to the universities in the U.S.A. for advanced training under the Technical Cooperation Mission Aid.

Conclusion: Thus, the institution started originally with a very modest aim, limited resources, facilities and staff, has grown up into one of the premier institutions of its kind for under-graduate and post-graduate studies not only in India and Far-East but in the world as a whole. Scientists of repute under the F.A.O., W.H.O., Indo-American Technical Cooperation Mission, etc., who visited this college were uniformly impressed with the course, the teaching, and the quality of work done. The investigation and research carried out in the college have resulted in the publication of more than 225 scientific articles.

Other institutions: Osmania University: Hyderabad established a College of Veterinary Science and Animal Husbandry in 1947 to meet the demand for qualified personnel to man the post-war development plans. This college now works on a shift system with a grant from the Indian Council of Agricultural Research to train up more personnel for the Five Year Plan needs. During 1955, Andhra State and Kerala State started a College of Veterinary Science at Bapatla and Trichur respectively. The former is affiliated to the Andhra University and the latter to the Kerala University.

PHYSICS

The history of Physics in South India during the present century is closely linked with the work of Professor C. V. Raman and his students, and it is only appropriate that we should start with the publication of Raman's first paper in 1906. This was based on his studies on the diffraction bands observed when light is reflected at almost grazing incidence on the surface of a prism. These studies were carried out when he was still a sudent of the post-graduate class in the Presidency College, Madras, and were published in the Philosophical Magazine for November 1906. Subsequently, Raman was lost to South India for some time, and during this period original work in Physics languished in this region for want of stimulus, although some interesting work was done at the Mysore and Andhra Universities, which will be referred to later.

In 1934, Professor Raman joined the Indian Institute of Science, Bangalore, as its Director and Head of the Department of Physics. He was instrumental in setting up a new school of Physics at Bangalore, and this was the beginning of a new era for Physics in South India. It may be truly said that advanced work in Physics in South India (for that matter, in the whole of India) has been stimulated, directly or indirectly, by Raman's influence. His students, or their students, occupy the chair in Physics in almost every one of the Universities in South India.

Establishment of Centres of Study and Research:

At the beginning of this century, instruction at the post-graduate level in Physics was confined to three institutions in this region—St. Joseph's College, Tiruchirapally. and the Presidency and Madras Christian Colleges, Madras. All three were mainly interested in teaching only, and very little attention was paid to research work. With the establishment of the Mysore University in 1916, a third centre was developed at the Central College, Bangalore.• By about 1910, the total number of post-graduates being trained in Physics was only about 7. In 1931 the Annamalai University had a post-graduate department at Chidambaram, and in 1932, the Andhra University at Waltair was added, In 1937, the Travancore University was established, thus adding a new centre at Trivandrum. With the establishment of the Karnatak University in 1953, and of Sri Venkateswara University in 1954, the number of universities in this region has become eight. At present, instruction at the post-graduate level (B.Sc. Honours or M.A. or M.Sc.) is available at Madras, Tambaram, Waltair, Hyderabad, Dharwar, Belgaum, Bangalore, Tirupathi, Annamalainagar, Tiruchirapalli and Trivandrum, which produce a total of about 195 post-graduates per year. In addition, specialized one-year courses after this level are offered at Madras in X-Ray Chrystallography and Statistical Mechanics, at Bangalore in Spectroscopy, X-Rays, Wireless and Nuclear Physics, at Waltair in Applied Physics and Geo-Physics, and at Annamalainagar in Spectroscopy.

Research Departments as such were not established at any of these centres until much later. The Astrophysical Observatory at Kodaikanal carried out research in Solar Physics under Evershed in 1909, but later it became a routine observational centre. C. V. Raman made some original investigations at the Presidency College, Madras, as already mentioned, but he drifted away and the College drifted into inactivity. During the 1920's the only active centre was the Central College, Bangalore, where some spectroscopic work was carried out by B. Venkatesachar and his associates. The Andhra University was also active in spectroscopy, mainly as a result of the work of K. Rangadhama Rao and V. Ramakrishna Rao. From the 1930's, the Andhra University became the leading centre of research in Physics among the Southern universities under the leadership of S. Bhagavantam.

After Professor Raman came to Bangalore, the Indian Institute of Science and later, the Raman Institute of Science, have been flourishing centres of research. The other universities have been, however, slow to catch up. Although Annamalai University had a research department in the 1930's, developed by S. Ramachandra Rao, it languished after his departure, and active research work has been revived there only recently by K. Venkateswarlu. At Trivandrum, a research department has been set up by C. S. Venkateswaran during the past decade.

After Bhagavantam moved to Hyderabad in 1949, the Physics Department of the Osmania University has rapidly expanded into an active centre of research. Among the old Universities

Madras was probably the last one to establish a research department of its own. Although research work in instrumentation and acoustics was carried out in the 1930's at the Presidency College under H. Parameswaran, the work was not continued after his departure in 1940. In 1952, a full-fledged research department was established in the University, with qualified staff both for experimental and theoretical Physics. This department has rapidly developed during the last five years, and Madras can now boast of a well equipped laboratory in X-Ray Physics and Crystallography, and an active school of workers in Mathematical Physics.

In 1953, N. R. Tawde joined the newly established Department of Physics at the Karnatak University, and under his guidance Dharwar is rapidly becoming a research centre for spectroscopic work. S. Ramachandra Rao, who was responsible for building up the Department of Physics at Annamalai University and later at the Central College, Bangalore, joined in 1954 the youngest of the universities in this region, Sri Venkateswara University, and work has been started in Spectroscopy, Ultrasonics and Ionosphere studies.

At present some 195 students are being trained to the post-graduate level. With the grants being provided by the University Grants Commission, these facilities are being expanded and a new centre is expected to be established at Madurai in the near future.

Crystal Physics and Scattering of Light

If any particular subject can be chosen as being the speciality of South Indian Physics, it is undoubtedly the field of crystal physics. The foundation for this field was laid by Raman's work at Bangalore on the optical, X-Ray, magnetic, elastic and thermal properties of crystals. The scattering of light in crystals has received a great deal of attention from the Bangalore school. It arose from the natural interest of this school in classical scattering and Raman Effect. The study of Raman Effect in crystals received a stimulus from the development by R. S. Krishnan of the use of the mercury resonance line (2537 AU) for the excitation of the Raman spectrum. Using this technique, the Raman spectrum of a large number of crystals have been recorded during the last ten years, including such standard crystals like NaCl, quartz and calcite. These data have formed the experimental basis for the theory of crystal dynamics developed by Raman. This theory maintains that the nature of the vibration spectrum of a crystal is to be ascribed essentially to the structure of the repeating unit of the crystal, and should have nothing to do with the external boundary of the crystal. This is reasonable, because there will be a very large number of repeating units (of the order of a million) placed end to end from one boundary to the other, so that the nature of the atomic vibrations at the centre of the crystal cannot be expected to be affected by the exact shape of the boundary, a million cells away. However, this theory has not met with universal acceptance, and further work is necessary before the controversy is settled.

However, the points of view of this theory and the earlier ones do not differ so far as the so-called elastic vibrations of crystals are concerned. It is these vibrations which lead to the classical scattering of light. They produce a very interesting effect on the spectrum of the scattered light. Since the waves have a finite velocity, and the scattering of light can be regarded as a sort of reflection of the incident light from the elastic waves, a Doppler effect is produced, and this results in the incident light of a single frequency to be split up into two components, one of slightly higher frequency and the other of slightly lower frequency. This phenomenon, which is known as the Brillouin Effect, was first experimentally demonstrated by Raman and his collaborators in Bangalore during the 1930's. The Brillouin doublets were recorded in solids, liquids and even in gases. Very recently, this phenomenon has been extensively investigated in a variety of crystals by V. Chandrasekharan, using the mercury resonance radiation. He developed a complete theory of the phenomenon in all types of crystals, and showed that, in the most general case, there should be 12 pairs of Brillouin-shifted lines and that they should exhibit special polarisation characteristics.

Simultaneous with the studies on the scattering of light and the Raman Effect of crystals, the infra-red spectra of a number of crystals have also been studied, mainly at Bangalore.

Perhaps the most interesting series of optical studies, though not in crystal physics, were those of R. S. Krishnan in the 1930's, on the polarisation of scattered light. He derived an important reciprocity relation, which shows that whatever be the nature of the polariser or analyser which is put in the paths of the incident or scattered beams, the resultant observed intensity of the scattered light is the same, when the directions of incidence and scattering are interchanged. Krishnan verified the relation for all states of linear polarisation, and recently it was verified for all general states of polarisation, at Bangalore.

Scattering of light and Raman Effect has been the subject of intensive study by S. Bhagavantam and his students, first at the Andhra University and later at the Osmania University. Bhagavantam is the author of an authoritative treatise on 'Scattering of Light and Raman Effect' and of an interesting book on 'The Theory of Groups and its Application to Physical Problems' in collaboration with T. Venkatarayudu.

During the last few years, molecular vibrations and the Raman Effect are being studied, and the force constants of different types of molecules have been evaluated at the Annamalai University by K. Venkateswarlu and his students.

Optics and the Theory of Dispersion

The theory of dispersion, as applied to crystals, has received a great deal of attention from G. N. Ramachandran and his collaborators at Bangalore. The most interesting result that emerges from these studies is that the so-called Lorenz field, if it exists, does not enter into the picture as far as the dispersion formula is concerned. The dispersion formula relates to the refractive index of a material with its dispersion frequencies, and if one uses the actually observed dispersion frequencies, then the relation can be put in the form of a Drude equation. This result can be verified by direct fitting of the experimental data to a dispersion formula, but is most clearly demonstrated when the data on the variation of refractive index with temperature or pressure are examined. Another field in which these ideas have been confirmed is the Faraday Effect (magneto-optic rotation) where again the data on the dispersion of magneto-optic rotation are found to fit only a Drude type formula. A large amount of data on the thermo-optic and piezo-optic constants of crystals have been obtained at Bangalore.

Magneto-optic rotation, both in crystals and in solutions, has been extensively studied by S. Ramaseshan and his colleagues at Bangalore. It is found that the magneto-optic anomaly, which is the ratio of the actually observed rotation to that predicted from the Larmor precession, is dependent on the nature of the chemical bond occurring in the material studied. In covalent compounds, the observed value is appreciably lower than that predicted by the above theory, but the two agree closely in ionic compounds. The magneto-optic method, as applied to crystals, has led to interesting new methods of determining piezo-optic constants.

Closely allied to dispersion is the phenomenon of natural optical activity, and this again has received a lot of attention at Bangalore, under the inspiration of Raman. Ramachandran developed a simple theory for crystals, based on the idea of polarisability of molecules. It gives the right order of the optical activity for quartz and sodium chlorate. The ideas have been applied to proteins recently at Madras. This particular theory is not suitable for discussing the dispersion of optical activity. The latter has been theoretically interpreted on the basis of coupled oscillator theory, by S. Chandrasekhar, who has thus arrived at a very simple formula, which fits a surprisingly wide range of observed data.

A beautiful optical phenomenon always caught the attention of Professor Raman, and a series of such phenomena observed in crystals have formed the subject matter of a number of papers by him and his students. Of special interest are his observations on Haidinger's rings in birefringent crystal plates, conical refraction in naphthalene and the iridescent colours of potassium chlorate. The theory of the colours of various natural objects, such as the plumage of birds, and iridescent colours of shells and of minerals, has been developed by Professor Raman. The physics of the phenomena is highly interesting in most cases, involving as it does ideas of interference, diffraction and scattering of light.

Crystal optics is considered to be an extinct field, in which there is very little new that is fundamental to be discovered. How false is this conception is shown by a series of brilliant papers published by a young worker, S. Pancharatnam, of the Raman Institute. He has shown that a careful study of the phenomena indicates the need for some new concepts, which are closely linked up with fundamental ideas of the polarisation states of light and of their superposition. In developing these ideas, he has made full use of the so-called Poincaré sphere and the Stokes parameter representation of the polarisation state of a light beam. Both these were known for a long time, but had not been utilised until recently when their usefulness in optical studies was pointed out by Ramachandran and Ramaseshan. These two authors are now engaged in writing an article on Classical Crystal Optics for the Handbuch der Physik, embodying these ideas.

Mention must be made of a series of studies on the diffraction of light conducted at Bangalore by Ramachandran. It was found that the value of the absorption coefficient of a scattering medium had been wrongly estimated to be half the correct value by earlier workers. This result was later obtained by other workers elsewhere both in the field of optics and in other applications. An elegant and simple method of working out the Fresnel diffraction pattern of apertures and obstacles of complicated shapes was worked out by Kathavate and Ramachandran and some extraordinarily beautiful patterns have been recorded.

Spectroscopy :

If any single discovery has brought scientific prestige and recognition to this region and to the whole country, it is the discovery of the Raman Effect. History was made when young C. V. Raman, then an 18-year old student of the Presidency College, Madras, published his first paper in 1906, in the Philosophical Magazine, London, 'On the Unsymmetrical Diffraction Bands due to a Rectangular Aperture'. It was in the fitness of things that this same brilliant student should, 22 years later, come out with one of the major discoveries of the Century. The Raman Effect, rightly regarded as a major break-through in the understanding of molecular structure, has been the subject of intense study throughout this region. Led brilliantly by Professor Raman himself, both in the experimental study and in the theoretical interpretation thereof, a very large number of papers have been published on the Raman effect of solids, liquids and gases. The Indian Institute of Science, Bangalore, has done pioneering work in this field, and under the guidance of Prof. Raman, a number of workers—notably, C. S. Venkateswaran, R. Ananthakrishnan and R. S. Krishnan—carried out extensive investigations in the 1930's on the Raman effect of a large number of solids and liquids, with a view to determining their molecular structure and vibrations. During the past decade or two, the tendency has been to concentrate almost entirely on the study of Raman Effect in crystals, since the sharpness of the Raman lines observed with crystals are capable of yielding data with the precision characteristic of spectroscopy, and help in the understanding of the theory of solids.

Spectroscopic studies in fields other than Raman effect have been carried out for a long time in this region, as already mentioned, at Bangalore in the 1920's and at Waltair in the 1930's. At present, every Research centre in this region is engaged in spectroscopic investigations of some sort or other. At Waltair, theoretical and experimental investigations are being carried out on the structure and interpretation of the atomic spectra of elements such as bromine, selenium etc., on the band spectra of diatomic molecules in the region from the photographic infrared to the vacuum ultraviolet (to about 1000 AU) and on the fluorescence and absorption spectra of polyatomic molecules, under the guidance of V. Ramakrishna Rao and P. Tiruvenganna Rao. The latter is also directing a scheme sponsored by the C.S.I.R. on the spectroscopic investigation of ocean bed samples. The microwave region of the spectrum is particularly suited for certain types of work, and at Waltair they have successfully developed a microwave laboratory under the direction of K. Rangadhama Rao. Most of the components required for the work such as klystron mounts, matching units, etc., have been locally rigged up, and techniques of generation and detection of microwaves down to 1 cm have been successfully developed. Most of the work done so far is mainly in problems relating to dielectrics. Absorption of microwaves in organic compounds, and the variation of the absorption coefficient with pressure have been studied. Investigations on nuclear magnetic resonance have been carried out using superregenerative techniques.

At the Karnatak University, active work on molecular spectra is going on under the guidance of N. R. Tawde. Intensity measurements of bands of various oxides, hydrides and radicals are made and these are used to deduce the transition probabilities and hence the mechanical anharmonicity and the variation of the electronic transition moment with internuclear distance. A microwave laboratory is being equipped for studies in the 3 cm band. At the Osmania University, Satyanarayana and coworkers are studying the effect of high current densities on the ionised spectral lines. The broadening characteristics of the lines produced by spark discharge are being studied in order to find a clue to similar broadening observed in the emission lines in the spectra of some hot stars.

X-Rays:

Next to optics, X-Ray Physics is the field most well developed in this region. The Indian Institute of Science, Bangalore, has been the pioneer in this subject also, and the first major discovery was the observation, by Raman and Nilakantan, in 1939, of the non-Bragg reflection in diamond, followed by similar observations in various other crystals. These authors correctly attributed the occurrence of such reflections to the vibrations of the crystal lattice. However, the detailed interpretations of the results, is closely tied up with the theory of vibrations of crystal lattices, which, as mentioned earlier, is still the subject matter of controversy. Following this, X-Rays have been used for a variety of experiments at Bangalore. An interesting application was for obtaining a topographic picture of the surface of the crystal (diamond), exhibiting the variation of texture over the area. Another application was to the development of the principle of an X-Ray miscroscope by Ramachandran and Thathachary. It is found that if a thin crystal, like mica, is curved to form a concave mirror, it would focus X-Rays just as it does light.

As is well known, the most important application of X-Rays is for the determination of crystal structures. The work in this line was initiated in 1949 by Ramachandran at Bangalore and has been continued by him at Madras later. At Bangalore also, there is an active group of workers led by S. Ramaseshan and R. V. G. Sunder Rao. In addition, an attempt is being made at Bangalore by G. Suryan to build up an analogue computer for performing the fourier syntheses required for crystallographic work. When this is completed, it would be a major triumph for the inventive ingenuity of Indian Physics. Some other analogue machines, for optical Fourier analysis, and in particular for the solution of linear simultaneous equations, are developed at Madras.

The first crystal structure to be determined was that of barium chlorate by G. Kartha, which has been followed by those of other inorganic compounds. Quite apart from the determination of the structures themselves, these studies have served as the basis for the development of newer techniques. Thus, the anomalous dispersion of X-Rays has been utilised in two different ways by workers at Bangalore and Madras. The former have used the variation in the real part of the scattering power to obtain a new modification of the so-called isomorphous replacement method. The advantage is that a pair of isomorphous crystals is no longer required, and a single crystal is sufficient for the determination. The latter have used the presence of the complex part in the scattering to obtain useful information, which could be obtained formerly only by trial and error methods. In addition, some very useful techniques for the solution of crystal structures have been evolved at Madras.

The fundamental theory of the interaction of X-rays with a crystal lattice has been the subject of study both at Bangalore and Madras. A simple but rigorous derivation of the well known Ewald-Darwin dynamical theory of X-ray reflection has been given by Ramachandran from an optical point of view. This has been later extended to explain a very surprising result, observed some years ago elsewhere, that the transmitted beam exhibits a sharp increase in intensity at crystal settings close to those at which the crystal reflects. Closely related to this is the influence of the polarisation of X-rays on the intensity of X-ray reflection. The theory of this is well known, but surprisingly no experimental verification had been made until recently. By building up a new type of X-ray spectrometer in which the X-ray beam is incident along the axis of rotation, Ramachandran and Ramaseshan were able to demonstrate all the predictions of the theory. The most interesting result is that the ratio of the intensity of reflection for parallel and perpendicular polarisation is not a constant for a crystal, but depends on the perfection (or mosaic structure or texture) of the crystal. Consequently, this has become a useful method for the study of crystal texture. Using this method, a large amount of data has been obtained for a number of standard crystals of varying texture by K. S. Chandrasekharan at Madras. Incidentally, this author also showed that it is possible to produce highly polarised X-rays whose perfection of polarisation is comparable to that produced by polaroids for light.

Structure of protein fibres:

A natural extension of the studies on crystal structure is that of biological materials, such as proteins. This is the main line of study at Madras and has led to the postulation of a structure for the fibrous protein, collagen—probably the first protein for which the structure is known to that amount of detail. The group at Madras have been attempting to apply all the physical methods available for the study of molecular and crystal structures, to the elucidation of biological structures. X-ray methods have figured prominently, but these are by no means adequate. Optical data, particularly on optical activity, are found to be highly valuable, as they provide information on the sense of helical arrangement of molecular groups in the fibre. Particular attention has therefore been directed to the application of the theory of optical activity to helical structures.

In addition to collagen, various other fibres are also being studied—feather keratin, chitin, nylon and some polymers such as poly-L-proline and poly-L-hydroxyproline. All of them seem to have many characteristics in common. As a result of these studies, it has been established that an entirely new type of lattice occurs in many of the natural fibres—the cylindrical lattice.

The studies on collagen have also been extended to include some other biologically allied materials. Thus, by treating collagen with solutions of salts which serve to partially disrupt its structure, new modifications have been produced by M. S. Santhanam, which exhibit a close resemblance to other proteins which occur in the animal kingdom—notably elastin. This result, deduced from X-ray studies, are confirmed by the electron microscopic observations made elsewhere. So also, a material showing the same X-ray pattern as natural bone has been obtained by treating collagen fibres with a suspension of precipitated calcium phosphate.

Ultrasonics:

Ultrasonic studies were initiated by Professor Raman at Bangalore in the 1930's. The first investigations were on ultrasonic velocities in liquids, measured by means of the diffraction of light by ultrasonic waves. The theory of the phenomenon was developed in a series of remarkable papers by Raman and Nagendra Nath and these cover practically all aspects of the problem studied so far—the intensity distribution for normal and oblique incidence of the light beam with respect to the ultrasonic beam, the influence of the ultrasonic intensity and so on. Later, measurements on the dispersion of ultrasonic velocity and absorption were made at Bangalore and more recently at Hyderabad and Waltair.

The ultrasonic method provides one of the most accurate methods for the determination of elastic constants of crystals, for the velocity of propagation of sound waves along any particular direction gives the value of a certain combination of the elastic constants. By making use of the measurements of sound velocity along different directions, all the elastic constants of a crystal could be determined. This technique has been developed and utilised to obtain a large amount of data by the school of workers under the leadership of S. Baghavantam, first at Waltair and later at Hyderabad. They have used a number of techniques based on the above principle. In the earliest one, they employed the diffraction of light by the ultrasonic waves to detect the occurrence of resonances in a crystal plate subjected to ultrasonic oscillations. More recently, they have also employed pulse techniques. In this way, crystals of various symmetries were studied, and the elastic properties of polycrystalline materials have also been investigated. Modifying Baghavantam's wedge method, B. Ramachandra Rao at Waltair has been able to excite shear modes of vibration and has determined the shear velocities in some common metals and rocks. In another modification, the same worker has used two identical progressive ultrasonic waves set up side by side in a column of liquid, and by moving one of them relative to the other by measured amounts he has been able to measure ultrasonic velocities in liquids accurately. At present, pulse techniques and optical methods are being employed at Waltair in the investigation of ultrasonic velocity, dispersion and absorption in high polymers.

Elastic Properties:

The relation of the elastic constants to the interatomic forces and the vibration spectrum of a crystal has been the subject of numerous studies by Professor Raman and his students, for the last 15 years. Rencently, in attempting to make the theory more exact, Raman and Viswanathan have arrived at a very important result, namely that the number of independent elastic constants for any crystal is larger than the number contemplated in the classical theory of elasticity. This new theory has also been worked out on a phenomenological basis by these authors. They believe that the stress and strain tensors at any point are not symmetric if a body is subjected to inhomogeneous strains. However, the expression relating the components of stress and strain is symmetric as between the two, as is to be expected from the reciprocity law of elasticity and the fact that the force system is conservative. As a consequence, one should consider $9 \times 9 = 81$ elastic constants, of which 45 are independent for a general triclinic crystal (and not 21 as in the classical theory). For a cubic crystal, it reduces to 4 (and not 3), and for an isotropic body to 3 (and not 2).

As already mentioned, a large amount of data on the elastic constants of crystals in the ultrasonic range have been obtained at a number of centres. frequencies up to 300 megacycles per second having been used at Waltair. For still higher frequencies, the light scattering method, using the magnitude of the Brillouin shift for different crystal orientations can be employed. This beautiful technique has been used by R. S. Krishnan and V. Chandrasekharan for diamond and for other crystals.

Thermal Properties:

The theory of specific heats is directly related to the theory of the vibration spectrum of crystals, and consequently, a great deal of attention has been paid to this subject by Professor Raman and the Bangalore group. A number of theoretical papers have appeared, comparing the predictions from Raman's theory with experimental data on the variation of specific heat with temperature.

Thermal expansion has, on the other hand, been the subject of a number of experimental studies. The first accurate measurement was that of R. S. Krishnan on diamond, using an accurate X-ray method. This was followed by measurements made by the interferometric method by his students on both isotropic and anisotropic crystals. These workers found that the Gruneisen law is not in general valid if a single characteristic frequency is employed for the crystal. In an attempt to make a closer comparison with the variation of thermal expansion and of vibration frequency with temperature, the latter has also been investigated for a number of crystals by recording their Raman spectra at varying temperatures.

At Madras, accurate studies on the thermal expansion of crystals of low symmetry at various temperatures have been made by the X-ray method. M. A. Lonappan has in this way succeeded in measuring the complete expansion tensor for the triclinic crystal of orthoboric acid, in addition to those of other crystals of higher symmetry. Some work on the determination of the expansion coefficients of cubic crystals by the X-ray method has also been done at Hyderabad.

The diamond:

Starting from about 1940, the diamond has been the subject of intensive study by Professor Raman and his associates. Diamond is the transparent crystalline modification of carbon, and one would have expected it to exhibit highly uniform properties in all specimens. On the contrary, it is found to exhibit enormous variations from specimen to specimen, particularly in its optical, electrical and X-ray behaviour. The mechanical, thermal and magnetic properties are not found to vary appreciably, which may possibly be due to the inherent limitations in the accuracy of such measurements.

The most striking variations are shown in the luminescence and in infra-red and ultra-violet absorption. While blue luminescent crystals are found to be opaque to the infra-red in the 3-micron region and the ultra-violet below 3000 AU, the green luminescent crystals are found to be transparent, while the non-luminescent specimens are transparent in the infra-red region of 3-microns and in the ultra-violet down to 2250 AU. It is tempting to suppose that the luminescence and absorption are due to the presence of an impurity. However, it is found by X-ray methods that the blue luminescent specimens show the highest degree of perfection in the crystal lattice, while the non-luminescent crystals are highly imperfect. These and other observations led Raman to propose that the wide variations observed are due to the fact that carbon occurs in different, but closely allied, modifications in diamond, and that these modifications coexist in any crystal of diamond. He has actually postulated the occurrence of four modifications, two having the highest (octahedral) symmetry and two having a lower (tetrahedral) symmetry.

A large number of studies have been made at Bangalore in an attempt to verify this theory during the decade 1940-50. A detailed account of these studies may be found in the two symposia published in the Proceedings of the Indian Academy of Sciences in 1944 and 1946.

Theoretical Physics:

Theoretical Physics and Applied Mathematics have not received much attention in this region until very recently, although Professor Raman and his co-workers have often worked out the mathematical details of their theories. In 1930, S. Chandrasekhar published some papers on the Fermi-Dirac statistics while he was a student of the Honours course in the Presidency College, Madras, but he later left India and unfortunately did not return to this country. Professor Max Born was working at Bangalore for a short period in the 1930's and some papers were published on quantum machanics under his guidance, notably by B. S. Madhava Rao and N. S. Nagendra Nath. Later, (in the 1940's), Professor H. J. Bhabha headed a cosmic ray research unit attached to the Indian Institute of Science at Bangalore, when a school of workers in theoretical nuclear physics was being developed. However, Professor Bhabha shifted his centre to Bombay, after a few years. In the Andhra University, a post-graduate course in Theoretical Physics was offered for several years.

Workers in crystal physics attached to Professor Raman and Baghavantam have sought to apply group theoretical methods to their problems. Some interesting theoretical methods, as applied to the theory of vibrations, crystal dynamics and the theory of diffraction and scattering of light have been developed under the inspiration of Professor Raman.

Theoretical physics could be said to have come into its own as a result of the establishment of a division of theoretical physics at Madras and of Applied Mathematics at Bangalore during the last five years. At Madras, the group of workers under the leadership of A. Ramakrishnan have been doing outstanding work on the theory of stochastic processes and their applications to various branches of physics. Ramakrishnan and his colleagues P. M. Mathews and S. K. Srinivasan have developed a number of new mathematical techniques, which are highly useful in the solution of specific problems, mainly by the use of the Laplace transform. In these methods, the physical aspect of the problem is kept in the forefront and it is found that the physical intuition supplies a very useful method of approach where more rigorous mathematical methods are found to be difficult. Thus many random processes could be physically represented by the integral or a two-fold integral, or n-fold integrals of a simple step function.

Apart from being satisfied with obtaining mathematical solutions to their problems, these workers have tried to numerically work out the results of their theories, e.g. the fluctuations in the number of electrons and photons in a cosmic ray shower have been worked out under various conditions. Recently, they have initiated work in quantum electrodynamics and have been engaged in calculating the cross-sections for multiple processes in electron-photon cascades.

At Bangalore, active work on problems in applied mathematics is going on under P. L. Bhatnagar.

Magnetic properties:

As mentioned under optics, magneto-optic rotation in crystals and solutions has been studied in Bangalore. In addition, the anisotropy and susceptibility of various crystals have been investigated at Bangalore by P. Nilakantan, and at the Annamalai University by S. R. Rao and co-workers.

Recently, G. Suryan has taken up the study of nuclear magnetic reasonance at Bangalore and has set up the necessary equipment. He is interested mainly in the effect of crystalline fields on paramagnetic resonance.

Radioactivity and Cosmic Rays:

The radioactive method is being used at Bangalore and Waltair for determining the age of rocks. These have been extended to marine sediments also at Waltair. Experimental work on cosmic rays was carried out for a few years at Bangalore in the 1940's. At present two units are working at Kodaikanal and Trivandrum for data-collection purposes as branches of the Physical Research Laboratory, Ahmedabad. A small group at the Madras Christian College, Tambaram, is studying primary cosmic radiation, and the flux of mu-mesons at sea-level, employing nuclear emulsions. They have also developed a method of processing thick nuclear emulsions, in small quantities, using a refrigerator for temperature control.

Cosmic ray theory, particularly as regards the distribution of energy in cascades, has been the subject of interest to the theoretical physics department at Madras. They have developed some entirely new techniques for this purpose, as mentioned earlier. A. Ramakrishnan is writing a book on 'Cosmic Rays' to be published by the Pergamon Press as one of their series of monographs under the editorship of Professor W. Heitler.

Ionosphere Studies:

Ionosphere studies have been carried out at the Andhra University under the guidance of B. Ramachandra Rao, and some interesting results have been reported. Employing the continuous wave transmission from Madras on the 31 metre band, arriving at Waltair by way of single reflection from the ionosphere, he has made a simultaneous record of the signal strength at three spaced points, which showed almost identical fading patterns, slightly displaced in time. Wind velocities and directions in the F-2 layer were estimated from these time displacements using a method of calculation similar to that in the spaced-receiver pulse method. Later, the fading records from four spaced receivers were employed to obtain an estimate of ionosphere wind velocities. The vertical movements of the E and F-2 layers and the horizontal drift of the E layer have also been investigated.

Study of the ionosphere during a solar eclipse is an important means of ascertaining the source of ionising radiation on the solar disc. The effect of the solar eclipse of 20th June, 1955, on the ionosphere was studied by B. Ramachandra Rao and S. Gopalarao, and some interesting results were obtained.

Miscellaneous:

A very interesting series of studies on Indian musical drums was undertaken by C. V. Raman and co-workers at Bangalore. These showed how the mridanga artiste excites the various harmonics of the membrane when he plays the instrument.

High vacuum techniques have been the subject of study by H. Parameswaran at the Presidency College, Madras. Some investigations on the acoustical properties of materials were also carried out under his guidance. Parameswaran was also responsible for training up a number of workers in skilled laboratory techniques such as grinding of optical surfaces. A course in Instrument Technology is being offered since 1950, at the Madras Institute of Technology.

Conclusion:

During the last year or two, a concerted attempt is being made to step up the standard of teaching at the post-graduate level in all the universities. Particularly at Madras, a new syllabus has been drawn up, covering the essential requirements both in theoretical requirements and experimental physics, and it is believed that this course can compare favourably with the courses offered anywhere at the Master's degree level. More graduates are also being attracted now-a-days to undertake research work, and it is hoped that before long, the output of original contribution from this region will register a significant increase.

ASTROPHYSICAL OBSERVATORY, KODAIKANAL:

Early History:

Although the observatory at Kodaikanal was established during the closing years of the nineteenth century, its history goes much farther back; for, it is really the successor to the old Madras Observatory which was started by the East India Company in 1792 "for promoting the knowledge of astronomy, geography and navigation in India". From this standpoint the Kodaikanal Observatory ranks among the world's older observatories devoted to what may be called modern or telescopic astronomy. From

1792 to 1891, while the observatory was functioning at Madras, it was responsible for many series of valuable observations, such as the long series of meridional observations of the brighter stars leading to the compilation of a general catalogue of 11,000 fixed stars. During this period of 100 years the observatory was directed successively by John Goldingham, T. G. Taylor, W. S. Jacob, W. K. Webster, J. F. Tennant and N. R. Pogson. Mr. Pogson, author of the formula connecting the luminosity of a star with its apparent magnitude, was succeeded in 1891 by Charles Michie Smith. It was during Mr. Michie Smith's tenure of the post of Government Astronomer—for, that was the official designation of the head of the Madras Observatory—that Kodaikanal was chosen for the site of a "Solar Physics Observatory for the systematic examination and study of the changes in progress in the sun and their correlation with the large features of Indian Meteorology", as recommended in a report submitted in 1881 to the Central Government by the Commission of inquiry appointed in connection with the disastrous famine of 1876-77. The foundation stone of the "Solar Physics Observatory, Kodaikanal", as it was then called, was laid in 1895 (one of the climateric years in the history of physics!) by Lord Wenlock, Governor of Madras. But the regular work of constructing the observatory's buildings really began only in 1898. On 1st April 1899, according to another recommendation of the Famine Commission, the Astronomical Observatory at Madras was transferred from provincial to imperial control. From that date Mr. Michie Smith, the former "Government Astronomer", became "Director of the Kodaikanal and Madras Observatories"; from the same date the astronomical work of over a century at the Madras Observatory practically came to an end, except for transit observations for time determination.

Successive Directors:

Some observational work began at Kodaikanal already in January 1900 and during the next eleven years of his directorship Mr. Michie Smith did much pioneering work in which he was assisted, from 1907, by Mr. John Evershed. In 1911 Mr. Evershed succeeded Mr. Michie Smith as director. Mr. Evershed retired in 1922 and was succeeded by Dr. Thomas Royds. On Dr. Royd's retirement Dr. A. L. Narayan became the director in 1937. Dr. A. L. Narayan retired in 1946 and was followed by Dr. A. K. Das, who continues to direct the activities of the observatory to the present day.

Pre-1947 Activities:

From its very inception the primary objective of the Kodaikanal Observatory was research in the physics of the sun, although its predecessor at Madras had fundamental or positional astronomy as its principal object of study. In common with other contemporary observatories, especially devoted to solar physics, the equipment of the Kodaikanal Observatory was comparatively simple, though of excellent quality. However, the instruments acquired during the first few years of the observatory's life at Kodaikanal continued to be its basic equipment up to the end of World War II, although a few minor additions were made from time to time. The observatory's outfit, though good and modern in the early days, therefore became progressively old-fashioned compared to the equipment of any top-rank solar observatory of the U.S.A. or Europe; for, the first half of the twentieth century was a period of unprecedented development in solar physics and in the wider science of astrophysics, both in their observational and theoretical aspects.

In 1909 Mr. Evershed, then assistant director of the observatory, made an important discovery according to which the gases in a sunspot flowed tangent to the sun's surface from the central region of the umbra towards the periphery of the spot in all directions; this radial velocity accelerating across the spot penumbra attained the enormous value of 2 Km/sec. or more at the outer edge of the penumbra and then abruptly dropped to zero. This phenomenon, commonly known as the "Evershed Effect", was completely contradictory to the idea of vertical motion in a sunspot around a central axis as proposed by Hale to explain the existence of a fairly strong magnetic field in sunspots discovered by him shortly before. Further work by Evershed at Kodaikanal and by St. John at Mount Wilson led to the elaboration of the circulatory system in the neighbourhood of sunspots which certainly helped to a considerable extent the understanding of the nature of the solar atmosphere, but it brought no nearer the solution of the problem of sunspot magnetism which even to this day remains one of the outstanding mysteries of solar physics. Another question to which Evershed devoted considerable time while at Kodaikanal was the study of the minute longward displacements of solar spectral lines compared to the same lines in terrestrial sources. At first he seemed to incline to the conclusion that these displacements were explicable on the basis of the red-shifts predicted by

Einstein's General Theory of Relativity; but with the progress of the years Evershed himself as well as other workers in the field came to believe that there was more to it than could be explained by the relativity theory, so that the observed red-shift of solar spectral lines continues to be another of the ill-understood, if not completely unsolved, problems of astrophysics.

Thomas Royds, who headed the observatory for 15 years, made notable contributions to solar physics and allied branches of astronomical spectroscopy. He continued the important work on the displacement of solar lines initiated by his predecessor and also obtained significant results from his studies of symmetrical and unsymmetrical lines in the solar spectrum and from his studies of the prominences on the sun's limb and the so-called "filaments" which are absorption markings due to prominences projected on the disk. In 1935 Royds detected the presence of the inferred triplet of free oxygen at λ 7770 in the spectrum of the sun's chromosphere and of prominences; this was the first time that these lines of the oxygen atom had been photographed in emission in the solar spectrum outside a total eclipse. In the nineteen-thirties when E. A. Milne's theory of line-contours became well-established as a powerful means of studying the constitution of stellar atmospheres Royds was among the first astro-physicists to begin seriously the measurement of the equivalent widths of Fraunhofer lines in the sun's spectrum.

After Royds, A. L. Narayan was director of the observatory for about nine years. His interests were mainly in atomic and molecular spectra; he himself, and his collaborators under his direction, made valuable contributions to the study of the spectra of doubly and trebly ionised lead, of the arc spectrum of arsenic, the first spark spectrum of bromine, the hyperfine structure of indium and thallium etc., and of the band spectrum of the phosphorus molecule leading to the conclusion that the P_2 molecule exists in the sun's atmosphere.

The present director's earlier work had been mainly concerned with certain theoretical aspects of solar physics. He had, from his studies of the dynamics of gases in the sun's atmosphere, been able to explain a large number of observed features of prominences, absorption markings, the reversing layer, the chromosphere and the corona. Although these theoretical studies have been pursued to some extent with the assistance of collaborators,

A. K. Das has, during the years following World War II, laid greater emphasis on experimental and observational research. In 1944-45 he had submitted to the Government of India proposals for the development of the Kodaikanal Observatory; these proposals were considered and generally approved and in some respects improved by the Postwar Planning Commission for Astronomy and Astrophysics presided over by the late Prof. M. N. Saha. Since India's attainment of independence our National Government has encouraged scientific research to an extent unknown in our country in former times. In recent years, the aim of the director of the observatory has, therefore, been to carry out the approved programme of development with the utmost zeal and expedition, while at the same time not to permit any slackening in the observatory's research activities. How effective the concerted effort of all connected with the observatory has been in this regard, despite the inevitable difficulties arising out of the inexperience of new staff, can be judged from a comparison of the scientific activities of the observatory before 1947 with its present-day activities.

Post-independence Developments :

Before 1947 the research activities of the Kodaikanal Observatory were almost entirely restricted to solar physics, so that the name "Solar Physics Observatory" was indeed very appropriate. However, during the ten years since independence the activities of the observatory have been enormously expanded, and in several directions, in order to exploit to the fullest possible measure the unique scientific advantages arising from its high altitude (2343 metres above M.S.L.) and from its proximity (geomag. lat. 0° ·6 N) to the geographical and the geomagnetic equators. Although solar physics continues to be one of its chief interests, the present functions of the observatory include many other equally important branches of astrophysics in its widest sense, such as stellar physics, radio-astronomy, cosmic radiation, ionospheric physics, geomagnetism, atmospheric ozone and so on. The present work of the observatory and the developments, already completed or planed, in the various fields of its activities * are briefly as follows:

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* **Meteorological and seismological observations are also regularly made at the Kodaikanal Observatory. Further study of these observational data is, however, the responsibility of other centres of the Meteorological Department.**

Solar Physics: Daily solar work consists of visual and photographic observations with a prominence spectroscope, a photoheliograph, a spectrohelioscope and two spectroheliographs. These observations are used for the preparation of daily solar maps and also for the compilation of solar statistics which are published with great regularity in the six-monthly Bulletins and Annual Reports of the observatory. Apart from the above instruments of daily observation, the observatory possesses a number of high-dispersion solar spectrographs using prisms and reflection gratings of the highest quality, almost all of which have been designed and built in the observatory during the last ten years or so with the help of optical components acquired from abroad. Most of the siderostats and coelostats needed for feeding these spectrographs with sunlight have also been designed and built in the observatory's machine-shop. A large (20-cm aperture) Lyot Coronagraph, a Lyot Monochromatic Filter (band-pass 0·65 A) and a very large Solar Telescope consisting of a Coelostat with three fused silica mirrors of 60-cm aperture and two telescope objectives of about 38-cm and 20-cm apertures and 36-metre and 18-metre focal lengths respectively are already on order with the best manufacturers in Europe and are expected to be available within a year or two. Many of the mechanical parts of the Coronagraph and of the Monochromatic Heliograph to be built with the Lyot Filter as its vital component, a spectograph for the Coronagraph and a very large spectrograph (focal length=18 metres) for the large Solar Telescope are planned to be constructed in the machine-shop of the observatory. Work on the construction of some of these instruments in the Observatory's workshops has already begun and the construction of the buildings for housing these ultra-modern instruments is well under way. The Coelostat of the Solar Telescope will be installed on a tower of about 10-metre height above ground, while the telescope objective and the spectrograph (which will be capable of rotating around its optical axis and of being exhausted of air) will be mounted horizontally in an underground tunnel maintained at constant temperature. When all these installations are completed, the Kodaikanal Observatory's solar equipment will be the best and most powerful that one can wish for, consistent with the present developments in instrument technology.

Stellar Physics: Work on stellar physics is a very recent addition to the activities of the observatory; the instruments at present available are of modest apertures, but of high quality. Stellar work, which now consists of visual and photographic observation of the planets and their spectra and of the spectra of the brighter stars, is carried out with the help of a 50-cm aperture Cassegrain Reflector by Grubb, a Refractor of 20-cm aperture by Cooke and a Grubb Astrographic Camera of 12·5-cm aperture. Both the Grubb Reflector and the Cooke Refractor had been lying dismantled with many parts missing for very many years, but they have been rebuilt during the last few years and put into regular service. Although a certain amount of useful work on planets and stars is being done with the modest equipment now available, the observatory's plans for the development of stellar physics work on modern lines include the acquisition of two great telescopes—a flat-field Schmidt-Cassegrain Telescope of about 88-cm effective aperture with a principal mirror of about 125-cm aperture and a conventional Reflecting Telescope of about 250-cm aperture. These two telescopes will be able to deal with most observational problems of stellar physics and cosmology for a very considerable time to come. As soon as one of these great telescopes becomes available, the 50-cm Grubb Reflector will be reserved exclusively for the photometry of stars, for which work it is admirably suited; a Kron-type photo-electric photometer has already been built for the purpose in the Electronics Laboratory of the observatory.

Radio-astronomy: Radio-astronomy at the Kodaikanal Observatory is only just beginning. The observatory now has two radio-telescopes for the metre-wave range which have been used for the study of radio-radiation from the sun and have yielded some interesting and new results. They were both built in the observatory's Electronics Laboratory. A receiver for radio-radiation in the centimetre range (10 cm.) has recently been acquired from the Radio-physics Division of C.S.I.R.O., Australia. An equatorially mounted, clock-driven paraboloidal antenna for this radio-telescope has been constructed in the observatory's workshop; the telescope is likely to go into service for studying solar radio-radiation as soon as a sufficiently stable power-supply becomes available at the observatory. The construction of a radio-telescope for the 21-cm. line-radiation of interstellar hydrogen is also projected.

Ionospheric Physics: The addition of a well-equipped ionospheric division with an attached electronics laboratory has been one of the important developments of the Kodaikanal Observatory during the last six years. Half-hourly vertical incidence soundings of the ionosphere over Kodaikanal are now made throughout the 24 hours with a Multi-frequency Automatic Ionosphere Recorder of a very up-to-date type. Field-intensity recordings on two selected wave-lengths are also made continuously.

Geomagnetism: From 1902 onwards a Magnetic Observatory under the Survey of India was functioning in the grounds of the Kodaikanal Observatory, but in 1923 it was closed down. After a lapse of 25 years the buildings of the old Magnetic Observatory were renovated and systematic observation of the geomagnetic elements was commenced from 1st November 1948. The equipment of the present magnetic division consists of two complete sets of magnetographs, one Watson and the other La Cour, in addition to the usual complement of instruments for the absolute measurement of the geomagnetic field elements. There are also an Askania Magnetic Horizontal Field Balance (with photoelectric recording outfit and both normal-speed and quick-run recorders) and a set of QHM and BMZ instruments. The equipment of the magnetic division will shortly be further strengthened by the addition of an Askania Vertical Field Balance and an Askania Earth Magnetic Recording Station of the most up-to-date design. The magnetic division of the observatory, already well-equipped, will thus have the best equipment that one can wish for.

Cosmic Radiation and Ozonosphere: Continuous recording of the intensity of cosmic radiation is made with an ionisation chamber of the Kolhörster type. A Dobson Ozone Spectrophotometer of the latest design has recently been added to the equipment of the Kodaikanal Observatory and systematic observation of ozone in the high atmosphere of the earth is now a part of the observatory's normal activities.

Machine-shop and Optical Workshop: From the equipment and activities of the observatory described in the foregoing pages it will be evident that a well-equipped machine-shop is a fundamental requirement. Such a machine-shop has in fact already been developed and is able to meet most present needs of the observatory in respect of construction of mechanical parts of instruments of research and observation. Steps have also been taken for organising an efficient optical workshop in which it will be possible eventually to make the optical components of astronomical and astrophysical instruments according to the observatory's needs instead of depending upon foreign manufacturers for everything; a modest beginning has already been made in this regard.

Scientific Cooperation: As a matter of national and international cooperation in scientific research some of the observational data collected at the Kodiakanal Observatory are supplied to various scientific interests in India and abroad. In accordance with schemes sponsored by the International Astronomical Union there are also regular exchanges of observational material between the Kodaikanal Observatory and other international observatories. At the invitation of the International Mars Committee, Kodaikanal Observatory cooperated in the observation of Mars during its 1954 and 1956 oppositions; its contributions to the I.G.Y. programme of observations now in progress will be of special importance. For the benefit of astronomers and geophysicists all over the world the solar, geomagnetic and ionospheric observations made at Kodaikanal are broadcast daily, in a special code, from the A.I.M.B.C. station at New Delhi. As soon as the Coronagraph is installed and the radio-telescopes are brought into regular service, information on the state of the solar corona and on the radio emissions from the sun will also be included in the daily A.I.M.B.C. broadcasts. For the information of the general public Kodaikanal Observatory issues warnings about anticipated ionospheric and geomagnetic disturbances through the Indian Press and the A.I.R., whenever occasions arise.

Research:

The Kodaikanal Observatory is primarily a research institution and therefore throughout its history the main emphasis has been on scientific work, although it has always been appreciated that no scientific organisation can function satisfactorily without an efficient administrative system. The routine observational work done at the observatory is intended finally for helping in research work, but much non-routine observational and experimental work is also done for special problems under investigation. Much of the daily routine observations in the various fields are published in the 6-monthly Bulletins of the observatory; some of them, in conveniently summarised forms, appear in the observatory's Annual Reports, in the quarterly issues of the Indian Journal of Meteorology and Geophysics, in the Bulletins of the Radio

Research Committee of India, in the Annual Reports of the Royal Astronomical Society of England and in certain international publications sponsored by the International Astronomical Union.

The results of research work done by the staff of the observatory are published as scientific papers forming special Bulletins of the observatory and in various technical journals in foreign countries as well as in India. With the recent developments in the observatory's instrumental equipment it has also become possible to train young men, fresh from the universities, in the methods of astrophysical research; a number of research scholars, who receive stipends from the Government of India Education Ministry, work at the observatory entirely on research problems. A very considerable amount of research work stands to the credit of the Kodaikanal Observatory.

PHYSIOLOGY

Although Physiology is a subject by its own right, the growth of this subject in South India, as in other countries, has mostly been as ancillary to medical sciences. The institution of a chair for Anatomy and Physiology in the Madras Medical College in 1847 could be marked as the beginning of the study of the subject in this part of the country. With the phenomenal growth of physiology it was found necessary to separate the chair of physiology from anatomy and this was done in 1867. To start with, Physicians of the General Hospital were appointed part time Professors of Physiology. The first whole-time Professor of Physiology was appointed in 1928. With the starting of other medical colleges, the subject came to be taught as a regular one for the first M.B.B.S. students. The subject is taught in great detail, for 18 months out of a total period of 4½ years for the course at the rate of 10 hrs. a week.

Another important landmark in the teaching of physiology has been the introduction of it as a subsidiary subject for B.Sc. The course was instituted in the Madras Christian College in the year 1937. This was closely followed by making it a subject for the Home Science degree course in the Queen Mary's College and the Women's Christian College in 1942. It has come to be recognised too, to some extent, that a knowledge of the fundamentals of physiology is a part of liberal education. In some of the medical colleges a course in physiology is offered for nurses, Sanitary Inspectors and others.

In the Madras Medical College, physiology is being taught for students studying for the degrees of B.D.S. and B.Pharm., and in addition, regular lectures in physiology are given for M.D. and M.S. candidates.

In most of the medical colleges facilities are available for advanced research in physiology. Several members of the staff have taken advantage of these facilities and have submitted thesis for Part I of M.Sc. in physiology. A few are engaged in work leading to a Ph.D. degree.

The outstanding research work carried out during the last decade in the different universities are listed below: —

MADRAS MEDICAL COLLEGE

During the last decade the facilities available in the Department of Physiology for research were made use of by the members of the staff and no less than seven of them submitted thesis as part I for M.Sc. in physiology. They are:

1. Dr. B. V. Subbareddy—Physiological studies of Vitamin K.

The physiological action of vitamin K on blood vessels, heart, on the movements of the alimentary canal, especially of the colon, coecum and small intestines was studied. The possible role of vitamin K in the economy of the organism was discussed.

2. Dr. C. Venkatramiah—Acid secretion *in vitro* in Frog's stomach.

The influence of certain ions on the gastric secretion of isolated stomach of frog were studied with particular reference to histamine.

3. Dr. K. P. Anandan—Studies on Experimental Hypertension.

Hypertension was induced in dogs by the Goldblatt technique i.e., by reducing the blood supply to the kidney by means of a clamp. The pathogenesis of essential hypertension was studied on these animals. The severe constriction of both renal arteries produced a condition similar to malignant hypertension in human beings. There were widespread haemorrhages in the gastro-intestinal tract, brain, spleen etc. The cause of these haemorrhages is discussed.

4. Dr. A. S. Murthi—Absorption of Monosaccharides from the intestine of rat.

The rate of absorption of monosaccharides from the intestines under experimental conditions was studied. The coefficients of absorption of these were worked out. The rate of absorption of glucose was much greater than that of xylose. Raising the body temperature reduces the rate of absorption. Calcium increases the rate of absorption. Sodium was without effect and potassium decreased the rate of absorption.

5. Dr. P. I. George—The action of Procaine Hydrochloride on the Cardiovascular system.

Intravenous procaine hydrochloride in doses of 2 to 6 mgm/kg. causes a slight decrease in the force of contractions of both auricles and ventricles. It also produces some reduction in the cardiac output (stroke volume). On the excised heart procaine hydrochloride produces a marked decrease in the rate of force of contraction and a decrease in the coronary blood flow. Intravenous procaine hydrochloride in doses of 2 to 6 mgm/kg. produces a marked fall in systolic and diastolic blood pressure and a slight fall in pulse pressure. It also produces vaso-dilatation in the splanchnic viscera and in the peripheral blood vessels chiefly in the cutaneous vessels. A slight decrease in the rate of force of contraction of the heart and consequently of the cardiac output is partly responsible for the fall in bood pressure. But these changes are observed only during the early part of the fall in blood pressure and returned to normal quickly, whereas, the low blood pressure persists for a longer time. It is, therefore, concluded that the fall in blood pressure following intravenous injection and procaine hydrochloride is chiefly the result of peripheral vasodilatation. Procaine hydrochloride antagonises the hypertensive action of adrenaline and diminishes the hypotensive action of acetylcholine.

6. Dr. H. D. Singh—Studies on the role of some afferent impulses of Respiration.

The relevant literature on the methods of studying respiratory mechanism and the role of afferent impulses in the regulation have been reviewed. The method of recording respiration, the experimental procedures and techniques employed have been described in detail. Some respiratory regions, the region of the carotid bifurcation, right side of the heart, upper abdominal organs, and the limbs were studied.

The results obtained are presented and conclusion drawn:

Afferent impulses from all these regions play an important role in modifying the rate, ventilation, costal, and abdominal movements in experimental animals. The significance and application of these experiments to respiration in human subjects in health and disease is discussed.

7. Dr. K. Sanjeevarao—The Carotid Sinus and Intestinal movements.

The effect of carotid sinus reflexes on the tone of the motility of the intestines was investigated. When the carotid sinus was stimulated by increasing the pressure inside the carotid sinus, by traction or when the sinus was directly stimulated, there was increase in the tone and motility of the intestine. Reduction of pressure inside the sinus resulted in inhibition of tone and movements of the intestines. It was shown that these effects were mediated through the splanchnic nerves and the sympathetico adrenal system plays a dominant role in such mediation.

In addition to these the following papers were published from the department:

1. Dinitrophenyl-Hydrazine colour reaction for Vitamin K.—Srinivasan, V., and Reddy, D. V. S.—*Current Science,* Vol. 17 pp. 22-23, Jan. 1948.
2. Health, comfort and efficiency of industrial worker in India—A review—Reddy, D. V. S.—*Ind. Med. Record,* Vol. 17.
3. Kata-thermometer reading in silver arrow (demonstration train) Reddy, D. V. S. and Lucas, J. K.—*Health,* June 1948.
4. Toxic substances formed during menstruation—Gupta and Reddy—*J. Ind. Med. Assocn.,* Vol. 19 pp. 37-38 Nov. 1950.
5. Histology of the skin of the Buffalow—Reddy and Subramaniam K. V.—*Ind. Vet. J.,* Vol. 27, pp. 18-22, 1950.
6. Microscopic structure of the suprarenal gland of the fruit eating bat of South India—Reddy and Sanjeeva Rao, *Ind. J. Physiology and Allied Science,* Vol. 4, 1950.
7. Studies in Fatigue and muscular performance in women during various phases of menstrual cycle—Dr. Mrs. S. Parvathi Devi and Reddy, D.V.S.—Paper read before Ind. Sc. Congress, Lucknow, 1953. *Proc. Ind. Sci. Cong. J.I.M.A.,* Vol. 23, pp. 13-15, Oct. 1953.

   The study was conducted on girls—using the Mosso's ergograph to record the fatigue of the flexors of the middle finger. The onset of fatigue at the premenstrual and menstrual phases was quicker and the work done by muscle less.
8. Adrenochrome—Physiological studies—Effect on cardiovascular system and intestinal movement. Srinivasan V., George P. I., Reddy D.V.S.—Paper read before *Ind. Sci. Cong.* 1953. *Curr. Science,* Vol. 23, pp. 176-177 June '53.

9. Studies on the Physiology of Nasal Passages—Measurement of relative patency and air flow on the two sides. *Indian J. Otolaryng.*—H. D. Singh, M. S. K. Rao, D. V. S. Reddy.—A simple method for simultaneous graphic recording of air flow through the two nasal passages and assessing the relative patencies is described.

10. Studies on the Physiology of Nasal Passages—Variations in the relative patency of nasal passages in apparently healthy individuals. H. D. Singh, M. S. K. Rao, and D. V. S. Reddy—*Ind. J. Physiol. and Allied Sciences.*—8, 145, 1954. The studies indicate that there are appreciable variations in the relative patencies of the two nasal passages from time to time during the day, even in healthy individuals, but no detectable or evident rhythm or pattern in these changes could be observed.

11. Studies on the Physiology of Nasal Passages—Effect of posture on the relative patency on air flow on the two sides. H. D. Singh, M. S. K. Rao, D. V. S. Reddy—*J. Ind. Med. Ass.,* 23, 548 (1954).

    The effect of posture on relative patencies was studied in healthy subjects and patients with nasal obstruction. No alteration was observed on changing from the standing to the sitting or sitting to the lying posture but when lying on the side, the dependent passage becomes narrower, while the upper of the two passages becomes wider.

12. Studies on Respiration—Effect on Respiration of afferent impulses from the upper respiratory passages. H. D. Singh and D. V. S. Reddy, *Ind. J. Otolaryng.,* 8, 1956. Abstract in *Proc. Ind. Sci. Cong.,* Pt. III. p. 409, 1956. The respiratory responses to stimulation of the upper respiratory passages (nasal, pharyngeal, and laryngeal mucosa) were studied in chloralosed dogs. Ventilation, costal and abdominal movements were recorded simultaneously. The results are presented and the possible afferent pathway discussed.

13. Role of afferent impulses from the lower abdominal organs on Respiration—H. D. Singh, *Proc. Ind. Sci. Cong.,* Pt. II, p. 410, 1956. The respiratory responses to mechanical stimulation of the lower abdominal organs (appendix, ascending colon and urinary bladder) were studied.

14. Aurticulo-respiratory reflex—H. D. Singh and D. V. S. Reddy, *Ind. J. Physiol. and Allied Science* (1956).
15. Studies on the Length of Menstrual Cycle (Dr. Mrs. Parvathi Devi.—*J. Obstet. and Gynaecol.*, Ludhiana, May 1956. This study was conducted on the women students of the preclinical classes of the Madras Medical College. Records were made month after month for four months of the date and time of onset of the menstrual phase and the cessation of the time. Factors like height, weight, diet, environment and age of onset of puberty were enquired into and their influence on the duration of the menstrual phase analysed.
16. Studies on the Age of Puberty on Indian Girls—*J. Family Welfare,* March 1956.

    It was found that the onset of puberty was influenced by the diet, and environmental conditions.
17. Studies on Basal Body Temperature during the Menstrual Cycle. *J.I.M.A.*, Nov. 1956.

    The thermal shift noticed by other workers at the time of ovulation, was found in the majority of girls between the eleventh and fifteenth day.

RESUME OF RESEARCH WORK DONE IN THE PHYSIOLOGY DEPARTMENT, STANLEY MEDICAL COLLEGE, MADRAS-1.

The Physiology Department started working independently in the Stanley Medical College from 1950 onwards and a series of research problems have been worked out. The following is a summary of work done in the department.

1. *Studies of Blood groups in South Indian subjects:*

This subject was taken up by Dr. A. Krishna Rao in 1950 under the guidance of the then Professor Dr. C. Vareed, M.B.B.S., M.Sc. The large amount of material available in the blood bank was utilized, and a systematic study of the blood groups in South Indian subjects was undertaken. The saliva of these subjects were also analysed for the determination of the titre value of the blood groups. Some anti Rh. serum was specially obtained from the U.S.A. and a limited study of the Rh. groupings was also made. The results of these studies were incorporated in a thesis submitted as Part I for the M.Sc. degree examination in Physiology, which was subsequently conferred on the candidate in 1952. The worker found significant differences in the blood groups of South Indian subjects from studies done elsewhere.

2. *Absorption of Vitamin C from the intestines*:

This study was undertaken by Dr. J. K. Lucas, and a special method for estimation of vitamin C content colorimetrically was evolved. A number of cases of scorbutic and normal rats were analysed.

3. *Physiological studies of adrenaline and nor-adrenaline and related compounds*:

These were undertaken by Dr. (Mrs.) Sarada Subramanyam and the results obtained were incorporated in a thesis submitted for Part I of the M.Sc. degree which was conferred in April '53. The results of these studies on the comparative action of nor-adrenaline, adrenaline and isoprenaline on the cardiovascular system and smooth muscle organs in different species indicated that there are large variations in the effects on various organs with important species difference in sensitivity.

Nor-adrenaline causes:

(a) parallel rise in systolic and diastolic BP with bradycardia,
(b) minimal cardiac stimulant action with no significant change in minute volume,
(c) general constriction of the vascular system with the possible exception of coronary vessels,
(d) no effect on oxygen consumption and general metabolism of animal,
(e) weaker inhibitory action than that of adrenaline on the smooth muscle.

Adrenaline produces:

(a) a well known rise in the systolic pressure with little action on the diastolic with tachycardia,
(b) a potent cardiac stimulant action in conjunction with increased minute volume,

(c) an overall vascular effect of vasodilatation, dilatation of the vessels of skeletal muscles, intestines and coronaries with constriction of the vessels of kidney, skin and spleen,

(d) general metabolic increase,

(e) a stronger inhibitory action on the smooth muscles of certain species.

Isoprenaline brings about:

(a) profound fall in BP with tachycardia,

(b) marked and sustained cardiac stimulation,

(c) dilatation of blood vessels,

(d) increase in O_2 consumption,

(e) powerful relaxation of smooth muscles.

4. *Endocrinological influence on the skeletal muscle*:

This study has been undertaken by Dr. N. Padmanabhan. Skeletal muscle activity was measured in terms of the response of the flexor muscle of the middle finger in the case of human beings and by a gastronemius preparation in the case of dogs, rabbits and other animals. An apparatus for the recording of the skeletal muscle contractions in these cases was evolved. By a series of cases involving the removal of various endocrine organs alone and in combination, as also by infections of various hormones in normal and subnormal animals, the effects of the influence of various endocrine glands on the work performance of skeletal muscle was evaluated. This work formed the basis for M.Sc. degree.

5. *Experimental and clinical studies on the Cardiovascular system*:

This was undertaken by Dr. K. Madhavan Kutty in which an assessment of the aetiological factors of hypertension were made. Hypertension was produced in animals not only by the classical Goldblatt method, but also by means of hormone administration (Doca), carotid artery constriction, sinus denervation, continuous saline infusion and other methods. The effect of hypotensive drugs was tested on these hypertensive animals of differing aetiological character. The effect of hypertensive drugs was also tried on normal and chronic hypertensive animals to compare the cardiodynamic effects produced. A study of the activity of the adrenal cortex under these various conditions was undertaken. The results showed that apart from the well-known renin-hypertension mechanism, a number of other factors may bring about hypertension, and that a judicious examination of the aetiology will narrow the horizon of essential hypertension considerably. The importance of hypothalamus and adrenal cortex in the production of hypertension was also disclosed.

Résumé of important papers published is given below :

1. Blood groups in South Indian subjects—Dr. Venkataramiah and Dr. Krishna Rao—*Indian J. Med. Sci.,* 1952.

A summary of a large number of cases of blood groups along with the titre concentration in the saliva, in South Indian subjects is given. The study revealed certain significant differences in the pattern of blood groups in South Indian subjects as opposed to studies conducted elsewhere. The Rh. groups have also been determined in a number of cases.

2. Blood pressure averages in South Indian subjects—Dr. (Mrs.) Sarada Subramanyam & Dr. K. Madhavan Kutty—*Indian J. Med. Sci.,* 1955.

In a review of more than 10,000 cases an analysis has been made of the average blood pressure readings in South Indian subjects and the relationship of blood pressure readings to other physiological factors like height, weight, age and sex. It was found that the average blood pressure reading of the South Indian subject was slightly below normal value (110/70). No significant relationship between blood pressure and other physiological factors could be made out in the study under review.

3. Analysis of urine in an inspected case of Pheochromocytoma—by Dr. (Mrs.) Sarada Subramanyam and Dr. V. Vadana Rao—*Indian J. Med. Sci.*—March 1956.

The results of analysis of urine and tumour tissue from a case of pheochromocytoma are presented. The urinary extract gave pressor activity in spinal animals. Further experiments proved that the pressor activity was due to noradrenaline and not to a mixture of adrenaline and noradrenaline. Increased amounts of pure noradrenaline is suggestive of an extra-adrenal tumour. At subsequent operation a tumour near the bifurcation of aorta lying over the 3rd and 4th lumbar vertebrae was removed. The extract of tumour also contained pure noradrenaline and since the noradrenaline content remained high even though the patient was free from hypertensive attacks, it is probable that some tumour tissue was left behind.

Research Work in Progress:

1. Excretion of catechol amines in normal individuals.
2. The role of noradrenaline in the aetiology of hypertension. This work was undertaken under the Madras State Research Scheme.
3. Noradrenaline and circulation by Dr. Sarada Subrahmanyam (1955).
4. Action of the commonly used analeptics on the peripheral vascular system—*Ind. J. Med. Sci.,* 1956 by Dr. V. S. V. Subbu and Dr. Sarada Subrahmanyam.

MADURAI MEDICAL COLLEGE

The Medical College at Madurai was started in July 1954. Dr. H. D. Singh, Head of the Physiology Department is conducting an investigation on "Study of pulmonary function tests", with the aid of a grant from the Madras State Research Committee.

RESEARCH WORK IN PHYSIOLOGY IN THE MEDICAL COLLEGES IN ANDHRA PRADESH

The Andhra Pradesh has five Medical Colleges, two of which started functioning only from this year. These two colleges are, The Mahatma Gandhi Medical College and Kurnool Medical College. The research work in physiology, carried on in the other three colleges is reported below.

THE OSMANIA MEDICAL COLLEGE, HYDERABAD

The Osmania Medical College, Hyderabad has Dr. C. Sitaramayya, M.B.B.S., M.Sc., Ph.D. (Lond.)., MPS (England) as Professor of Physiology and Dr. Simhadri, M.B.B.S., M.Sc., as Reader. The research work done by them prior to their coming over to this institution has been included elsewhere. In the Osmania Medical College itself the following research has been done during the last 10 years. This has been incorporated in the papers given below;

1. An analysis of the electrocardiogram obtained with the standard limb leads from 75 healthy young men at Hyderabad. S. A. Rahman—*Ind. J. Physiol. & Allied Science,* Vol. 1, No. 2, p. 1, 1947.
2. Myocardial infarction showing special features—S. A. Rahman. *Indian Heart J.* 1953, 5: 153.
3. Effect of cooling the anterior chest wall on the T wave of the electrocardiogram—S. A. Rahman, R. N. Abhyyankar and Taher Ali. *Amer. Heart J.,* 47: 394, 1954.

   Abstract: Cooling the precardial area of the chest wall gives rise to primary T wave changes. It is suggested that these changes are due to delayed repolarisation of the epicardial surface of the anterior wall resulting from actual cooling of the surface of the heart in this region.

ANDHRA MEDICAL COLLEGE, VISAKHAPATNAM

Research work during the last 10 years:

1. *Histological study of the endocrine organs of Pteropus edulis by Dr. C. Sitaramayya, M.B.B.S.* (1947-'49).

It was observed by usual methods of fixation and staining that the histological features of the endocrine glands of this mammal were in general similar to other mammals.

2. *The influence of vitamin C on the work performance of the skeletal muscle by Dr. P. Brahmayya Sastri, M.B.B.S.* (1949-'51).
   - (a) On human subjects
   - (b) On guinea-pigs.

(a) The work performance of the flexor muscle of the middle finger was studied ergographically in human subjects. A state of partial and complete saturation in respect of vitamin C was produced in these subjects by administering suitable doses of L.-Ascorbic acid and the effect of the same on the work performance of the skeletal muscle was studied.

(b) The work performance of the gastrocnemius muscle in the guinea-pig was studied under different conditions of nutrition of the animal in respect of vitamin C, namely:

(i) in the normal state
(ii) in the scorbutic state
(iii) in a state of partial or complete saturation with vitamin C.

As a result of these studies it was found:

(i) The concentration of vitamin C in blood plasma fell to zero on the 17th day on scorbutic diet.

(ii) The work performance of the skeletal muscle was increased during the scorbutic state except on the last two days before death due to scurvy when it was considerably reduced.

(iii) The work performance was markedly reduced in the case of animals that received partial and full saturation doses of vitamin C.

(iv) The optimum after-load for the skeletal muscle and the concentration of vitamin C in the muscle and the adrenals were highest in the case of animals that received $\frac{1}{18}$ saturation doses while those that received $\frac{1}{6}$ and full saturation doses showed lesser values.

3. *Studies in respiration in dog and in man by Dr. G. Ramadoss M.B.B.S.* (1952-'55).

The respiratory patterns in the conscious dog and in the anaesthetised dog were studied, and the influence of:

(i) The nervous and chemical types of stress.
(ii) The role of neck muscles inserted into the upper part of the chest.
(iii) The role of the phrenic nerve

were determined in the anaesthetised dog by recording the costal and abdominal respiratory movements stethographically.

As a result of these studies it was found that:

(i) in the majority (86%) of dogs the eupnoeic respiratory pattern was costoabdominal.
(ii) the respiratory pattern under anaesthesia changed from the costoabdominal type of the conscious state to the abdomino costal pattern.
(iii) the nervous stress induced by stimulation of the peripheral nerves produced an increased amplitude in the costal and abdominal movements in both inspiratory

and expiratory directions, while that induced by chemical stress increased the amplitudes of the costal and abdominal respiratory movements mainly in the inspiratory direction.

(iv) the severence of the neck muscle attachments to the upper thoracic cage did not affect the respiration.

(v) in dogs under anaesthesia acute bilateral phrenictomy reversed the abdominal type of respiration into a costal one.

Respiratory patterns in changing posture were studied in 57 male subjects. As a result of these studies it was found that:

(i) the respiratory pattern in the standing posture was mostly abdomino-costal

(ii) in the sitting posture it was either costo-abdominal or abdomino-costal

(iii) in the lying posture it was almost invariably abdomino-costal.

4. A study on the influence of vitamin C on the work performance of skeletal muscle by Dr. P. B. Sastry (Proceedings of 40th Indian Science Congress Part III. Abstracts Section XI. Physiology. 95th item, pp. 271-272, 1953).

MEDICAL COLLEGE, GUNTUR

The Physiology Department of this College started functioning from July 1947 and during eleven years, the department has been considerably improved with up-to-date research and library facilities for post-graduate studies. 50 students were admitted originally which has now been increased to 100.

Research done:

1955-56 (1) An investigation of physiological normals of South Indian adults.

(2) Haematological changes during menstrual cycle.

Papers read in the 43rd Indian Science Congress, Agra '56:

1. Progressive development of the motor innervation of the respiratory muscle of Human foetuses—by Drs. Simhadri & C. Sitaramiah.

2. Relation between haemodynamics, sex and age in young South Indian adults—Drs. C. Sitaramiah, Syamala & Venkatasami.

Dr. Simhadri submitted his thesis for M.Sc. degree on the "Innervation of respiratory muscles of the human foetuses".

1956-57 *and* 57-58:

1. Study of the aetiology of ovarian contraction and their significance in the mechanism of ovulation.
2. Instances of child birth and still birth in relation to the climate of Guntur.
3. Studies on leucocytes with special reference to eosinophils among tobacco workers.

Papers published:

Mesovarian contraction in frogs—by Dr. A.S.R.K. Haranath, M.D., and Dr. A. S. R. Murthi, M.B.B.S., M.Sc.—*Ind. J. Physiol. & Allied Sciences,* Vol. **10**, April '56.

MYSORE UNIVERSITY

The Physiology Department in the Medical College at Bangalore (Mysore University) was started only 1½ year ago. Dr. C. Vareed, M.B.B.S., M.Sc. is the Professor of Physiology.

In this short period the members of the teaching staff have launched on research work reported below:

Two Phases of Salivary Secretion—By J. S. Saksena & S. Narayan:

Ten minute samples of saliva were collected at half-hourly interval from student volunteers while fasting and after a test feed. In addition to the pH and volume, the time required for digestion of 4 ml. of 1% starch solution to erythrodextrin and then to products giving no colour with Iodine was noted. It was repeated with another portion of the same starch solution to which 0·9% sodium chloride had been added.

It was shown that the salivary secretion occurs in two phases: (1) Buccal or nervous phase—This is reflex in origin and the quantity and quality of saliva in this phase depends on the physical state and taste of food. There is no marked rise in pH and the salivary chlorides increase with the rate of secretion.

(2) Gastric or humoral phase—A more prolonged phase in which the salivary composition is conditioned by Gastric Secretion. The pH tends to rise and the chloride content falls.

The two phases overlap to a variable degree.

Percentage of Carbon-dioxide in "Alveolar Air" amongst Indians—by J. S. Saksena.

In a series of observations made on human volunteers—medical students and members of the staff, it was found that the percentage of carbon dioxide in alveolar air amongst Indians is lower than the figures reported by British and American workers. The figures in 96 volunteers are given which range from 4·86% to 5·36%, with an average of 5·16%.

Prof. Mathur's method was used in collecting the alveolar air samples which were analysed by the Haldane's air analysis apparatus.

A probable cause for the lower figures in Indians is suggested and further line of work is indicated.

Gastric acidity and urinary chlorides—By S. Narayan, J. S. Saksena & S. V. Venkatarama Rao.

Half hourly samples of urine were collected in 25 student volunteers, under fasting conditions and after giving 25 ml. of 20% alcohol. Some volunteers were given 25 ml. of water to serve as controls.

The volume, pH, and chloride content of urine were noted.

The experiment was repeated in dogs giving 4 units of insulin as stimulant to gastric secretion. The urine samples were collected by means of a rubber catheter introduced into the urinary bladder.

The urinary chlorides were found to fall on giving the test feed. The fall was greater than that due to the diuretic effect of water in the test feed, as observed in the controls. This was confirmed by the animal experiments, where the urinary chloride content fell in spite of the urine volume being below the initial figure.

It is proposed to collect samples of gastric juice and urine simultaneously and to estimate the total and free acid in the gastric juice, and urea and chloride content in urine. The chloride in urine is to be reduced to a constant urea value to see if there is any quantitive correlation between gastric acidity and urinary chlorides and whether the latter could replace gastric analysis as a clinical investigation.

TRAVANCORE UNIVERSITY: MEDICAL COLLEGE

This institution being comparatively new, only a few lines of research have been undertaken in the Department of Physiology. A series of papers have been published in the Indian Journal of Medical Research and Current Science on blood amino-acids in health and disease, using paper chromotographic methods. A paper on "Lipids in Retina" was published in the Journal of Comparative Neurology (1955). A scheme of research into the Nutritional Status of mother's milk and the blood amino acids is being planned under the I.C.M.R.

ANNAMALAI UNIVERSITY

In the Annamalai University, the Department of Zoology has been interested in research in comparative physiology and physiology of development. This department has adequate equipment especially for (1) chemical physiology of digestion (2) metabolic studies at tissue level and also at cellular level (3) physiology of nervous system in lower animals.

The following problems have been investigated during recent years.

1. Physiology of digestion in *Pila virens* (Published).
2. Physiology of digestion in *Melania crenulata* (Published).
3. Physiological studies of *Pila virens* with special reference to aestivation (Partly published).
4. Physiology of digestion in *Mugil, Boleophthalmus* and *Sciaena.*
5. Lipids and amino acids of *Boleophthalmus* and *Mugil.*
6. Amylases of Mullets (Under publication).
7. Effect of insulin on the amino acid metabolism of *Ophicephalus striatus.*
8. Respiration of *Pila*—developmental stages (as a part of chemical embryology of *Pila virens*).

"Highlights of Achievements":

The outstanding feature is the investigation of the "Physiology of aestivation of *Pila virens*", which has been considered (by Dr. B. T. Scheer, Dr. Theodor Von Brand and Dr. Frank A. Brown) as a "substantial original contribution to biological science" and "as a valuable addition to comparative physiology". The controlling factors of aestivation metabolism have been traced to a steroid hormone in the cerebral ganglia of the snail.

PSYCHOLOGY

Mysore University

Mysore University has the distinction of having started the first Psychological Laboratory in the South. Late Dr. M. V. Gopalaswamy started the Psychology Department at the Maharaja's College, Mysore. The department undertakes teaching for the Degree Classes and also caters to Research students upto the Doctoral level. Dr. Gopalaswamy made significant contribution to our understanding of humour, the two factor theory, the PGR and the function of values in personality structure. The Department is now headed by Dr. B. Kuppuswamy. The Staff have published number of papers on Counselling, Para-psychology, Educational Psychology, Abnormal Psychology etc. The Department also publishes a journal by name 'Psychological Studies'.

Madras University

With the initiative of the Vice-Chancellor Sir. Dr. A. Lakshmanaswami Mudaliar, the University decided in the year 1943 to institute an Advanced course in Education leading to the M.Ed. Degree, the four Teachers Training Colleges in the city and the University participating. The University agreed to offer the required instruction and laboratory training in Advanced Educational Psychology, theory and practical. To meet this immediate requirement, Dr. G. D. Boaz, was appointed and he subsequently became the Professor and Head of the Department of Psychology. The Department has Dr. T. E. Shanmugam, as Reader.

In the year 1950, the University decided to institute the Honours course in Psychology, with the Presidency College, Madras, and the Madras Christian College, Tambaram, and the University Department of Psychology as the co-operating units.

The Department provides training and instruction in two subjects for the Honours course and in Advanced Educational Psychology for the M.Ed. Degree course. The M.Ed. students have to submit a thesis as partial requirement for their examination. Those who take psychological topics for their theses work under the guidance of the staff of the Department.

The Department also has its regular quota of Departmental Research students, ranging from two to four new admissions every year.

During the last five years, the Department has also been undertaking research on behalf of the Government of India on various problems. At present four research assistants are working on three different problems.

So far five research students have been awarded M. Litt. Degree on the basis of their work done in the department.

The M.Ed. theses of 21 students supervised in the department have also been accepted so far.

DETAILS OF RESEARCH WORK

1. *Accepted M. Litt. Theses:*

Studies in Children's Drawings.—A. K. Meenakshi (1946).

An Analytical Study of Juvenile Delinquents and Adult Criminals—T. E. Shanmugam (1946).

Problems of Mental Hygiene in Schools—Irene Manuel (1950).

A study of some inmates of the Madras Vigilance and Rescue Homes with special reference to their personality structure—A. K. Srimathi (1954).

A Study of marriage rituals in some South Indian Communities—V. C. Vimala (1956).

A Study of Children's fears—Rajalakshmi Varma (1957).

2. *Accepted Report of work done by the Research students in the Department:*

A Comparative Study of Day Scholars and Resident Pupils with reference to their achievement and personality development—H. D'Souza.

A Critical Study on the concept of Intelligence—A. S. Narayana Pillai.

An Analytical Basis of Personality and projective studies and Behaviour—E. I. George.

Negative phase in the development of personality—T. E. Shanmugam.

Language Development of Children between ages 7 and 12—Ramachandran.

Wit and Humour in Malayalam Literature—D. Verghese.

Reasoning in Schizophrenics—K. A. Sumitran.

Attitude of parents towards bringing up children—R. S. Patel.
Social Behaviour in Children—Mary K. Oommen.

Mother - Child Relationship—A cross - cultural - study—J. Dumas.

Problems relating to Adolescence—R. I. Bedford.

3. *Accepted M.Ed. Theses*:

Religious instruction in a National System of Education.

An Enquiry into the vacational sense of an un-selected group of S.S.L.C. Students.

A study of Juvenile delinquency in the City of Madras and in the District of Chinglepet.

Friendship amongst High School boys, basis of formation and rejection.

Man concept test as an Intelligence Test.

A Study of Musical ability in High School children.

Study of some Personality traits in residential and non-residential students.

A Study of Emotional stability in High School boys in South Travancore.

A Study of development in imagination in children between ages 8 and 11.

The Problem of the Bright Child.

A Study of reading interest in English medium schools in Madras City.

Backwardness in some Madras schools.

Attitude of non-professional married women graduates to their University Education.

Some Personality Problems of Deaf and Dumb children.

An enquiry into the backwardness in achievement of some pupils in Ceylon Schools.

A Study of character and social development in relation to deviation in age.

A Study of Problem and Order and Discipline in some schools in the City of Madras.

Studies in suggestibility with reference to intelligence and sex differences.

Emotional Factors in the Reasoning of children.

The Man Drawing Test as a measure of intelligence adapted and standardised for use in the primary schools of Travancore.

A Study of recidivism amongst delinquents.

A Study of some personality traits of orphan and non-orphan children.

Reading interests in the High School students in Madras.

Development of imagination in Adolescence.

Studies in Recall in children.

4. *Government of India Projects*:

Completed: The Reactions of Socially Backward People to various Ameliorative Measures.

A Study on the Probation system in Madras State.

A Study of the Adult and Social Education in the Community Development Projects.

In Progress: Standardisation of Intelligence Tests.

Papers published by Dr. T. E. Shanmugam:

'An Analytical Study of Delinquents'.—Indian J. Soc. Work 1948, *9*, 176-184.

'A Study of Adolescent Phantasy'—J. Madras Univ. A, 1950, 44-68.

'The Verbal Projection Test Stories and the Thematic Appreciation Stories'—J. Madras Univ., A, 1951, *22*, 106-118.

'Characteristics of Adolescent Girls' fantasies'—J. Madras Univ., B, 1952, *22*, 119-128.

'A Study of Emotional Instability in Adolescence'—J. Madras Univ., A, 1953, *24*, 30-40.

'A Personality Inventory—Its Reliability and Validity'—J. Madras Univ., B. 1953, *23*, 252-258.

'The Thematic Appreciation Test and Cultural Factors'—(in colaboration with Dr. G. D. Boaz)—Awaiting publication.

'A Report of the Analysis of Responses to the Personality Inventory of Boys from low Socio-Economic Families', J. Madras Univ., B, 1954, *24*, 372-384, 'The Verbal Projection Test and the Estimates of Teachers and Parents'—J. Madras Univ., B, 1955, *25*, 271-283.

'Symptoms of Emotional Instability in Adolescent Boys of low Socio-Economic Families'—J. Madras Univ., A, 1956, *27*, 81-114.

'Sex Delinquency and Emotional Instability in Women'—Ind. J. Soc. Work, 1956, *17*, 30-43.

'The Verbal Projection Test Stories of Delinquent and Non-Delinquent Boys'—Psychol. Studies, 1956, *1*, 40-50.

'Covert and Overt Personality'—J. Psychol. Research, 1957, *1*, 32-46.

'Verbal Projection Test Stories of Delinquents and Non-delinquents'—*11*, Psychol. Studies, 1957, 2.

'Effect of Socio-Economic status on Emotional Instability'—J. Psychol. Res. 1957, *1*

Book :

'Environment and Man' (Tamil) Madras : Chintanai Publishing Co. 1957.

Publications by Dr. G. D. Boaz :

"Know Your Mind" . . . . Central Art Press, Madras.
"Elements of Psychology" . . . -do-
"General Psychology" . . . By the Author.

PRESIDENCY COLLEGE, MADRAS

The Psychology Department of the Presidency College teaching upto the M.A. standard, is headed by Prof. S. Parthasarathy. The Department is recognised for Advance Research work. It has a well equipped laboratory.

MADRAS CHRISTIAN COLLEGE.

This college has a separate Department of Psychology teaching upto M.A. standard. Former Professor of Psychology of this college, Dr. S. P. Adinarayan has the following publications to his credit :

'The Psychology of Colour Prejudice', British Journal of Psychology, Vol. 31, pp. 217-229.

'What is behind Race Prejudice'? Y.M.C.A., Calcutta, 1952.

The Human Mind, Hutchinsons University Library, Hutchinsons, London, 1952.

'Before and After Independence—A Study in Racial and Communal Attitudes in India', British Journal of Psychology. Vol. 44, pp. 108-115.

'The Cognitive Background to Prejudice. Psychological Studies', Mysore University. Vol. 2, No. 1.

Dr. C. T. Krishnamachari, the present Head of the Department of the college has the following publications to his credit:

'Para-psychology & Quantum Physics'. J. Para-psychol. September, 1956, (Duke University, U.S.A.).

"Postscript to the paper', J. Para-psychol. April, 1957.

"Is 'Mind' Extended in an imagery space". J. Ind. Phil. Association, April, 1957.

'On Hypotheses about Psychic Spaces', Ind. Phil. Quart., April 1957.

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At the initiative of the Teachers of Psychology in the Madras Colleges, a Society for the promotion of study of the subject has been formed in Madras under the name :

"The Madras Psychological Society".

This Society has recently undertaken to publish a Research Journal by the name "Journal of Psychological Researches".

OTHER SOUTH INDIAN UNIVERSITIES

In the other South Indian Universities, there is no separate Psychological Department, and the subject being taught as part of the course in Philosophy. However, Kerala University has just recently opened a separate Department in Psychology with Dr. E. I. George, as its Head.

In Annamalai University the Reader, Mr. D. I. Jesudasan, has published a paper on 'Mysticism and ambivalence', in the Journal of the Annamalai University.

STATISTICS

A review of the growth and development of statistical education and statistical activities in South India given in this section contains an account of the place of Statistics in higher education and research in different universities and an appraisal of the activities of statistical organisation of various States included in the region.

The place of statistics as a subject of study for university courses can fully be appreciated if it is recognized that most of the significant contributions to statistical methodology responsible for considering it as a separate branch of scientific knowledge belong to this century. The rapid expansion of the subject brought in its wake the scope of its varied applications in all quantitative studies in applied and social sciences and technology. These two factors together with the organizational differences that exist among universities in South India have resulted in lack of similarity among the courses offered in statistics in these universities. Not only are there wide differences in the importance given to statistics in the degree courses, but even among parallel courses there are considerable variations both in the content and in fixing the eligibility of candidates for admission. While this subject is given hardly any place in Osmania and Sri Venkateswara Universities, it has received due recognition as a separate branch of knowledge in other universities. Since a study and intelligent understanding of statistical methodology requires a background of Mathematics, this subject was introduced first for the degree courses in Mathematics. Soon, the recognition of a knowledge of Statistics as an essential requirement for all experimental sciences resulted in the introduction of elementary courses in this subject with particular reference to the main subjects in degree courses in Economics, Physics, Psychology, Education, Medicine and Technology. This zeal to introduce Statistics in some form or other as a subsidiary subject in different degree courses appears to have been much more than to provide courses offering Statistics for main study. However, a rapid introduction of this subject in a variety of courses without developing sufficiently the basic courses leading to the main graduate and post-graduate degrees is likely to give rise to some problems. Mysore and Annamalai Universities started degree courses in Statistics very recently, whereas in Madras University the parallel course was provided only in early forties in three of the affiliated colleges. Taking into consideration the turnover of graduates with Statistics as main subject, the numbers are very small compared with the numbers of graduates in other subjects. This can primarily be attributed to lack of adequate number of institutions offering these courses. Even for the few that take a degree in Statistics very limited openings are provided among South Indian universities to get further training either in theoretical or in applied Statistics.

With the complete reorganisation of university courses, Statistics is given a place as a main, ancillary and minor subject of study for the three-year B.Sc. courses. In addition this subject is introduced for the degree courses in Economics, Psychology, Commerce and Textile Technology. A course of lectures in Statistics without any examination is made a part of the syllabus for pre-professional courses in Medicine, Agriculture and Veterinary Science. This new degree course offering Statistics as a main subject is introduced in three colleges in the University of Madras and in some colleges in Kerala University.

The variations among honours and post-graduate courses in Statistics offered by different universities are much more significant than those noted for the degree courses. Thanks to the lead taken by a British mathematician who was Professor in the Madras Christian College, Statistics was first introduced as a special subject for the Mathematics Honours course even as early as 1920 in that institution and was closely followed by the Pachaiyappa's College. This promising beginning, however, had not led to the provision of Honours and post-graduate courses in Statistics with facilities for research in the University of Madras. Mysore University took the lead in this matter by appointing a Professor of Statistics as early as 1923 and starting the Honours course with Statistics as an important subject of study in 1929. This was later modified and replaced by a B.Sc. (Hons.) course in Statistics in 1942. Along with it, a post-honours one-year course in Statistics was started leading to the M.Sc. degree by examination. Travancore University, since its inception in 1937, provided Statistics as a subject of study for the Honours course in Mathematics. It was in 1944 that a separate Division of Statistics was created for higher teaching and research in the University and along with it a two-year post-graduate course leading to the M.Sc. degree in Statistics was started in the following year. This course is open to those who take Mathematics for the degree course. In 1951 both the Andhra and Karnatak Universities created Departments of Statistics and introduced M.Sc. courses in Statistics by examination. While the course offered by Karnatak University is similar to the one provided by the Travancore University, being post-degree studies for two years, the Andhra University designed the M.Sc. as a two-year post-Honours course open to students who took the Honours degree in Mathematics or in Economics. Being an affiliating University, the introduction of the B.Sc. (Hons.) course in Statistics had to wait till 1949 in the University of Madras, although a provision was made for it even in 1942. This course is being offered by the only institution, Presidency College, Madras, that started the course in 1949. The content of this B.Sc. (Hons.) course is not similar to that of the corresponding course offered by the Mysore University. No admission is made for post-graduate studies and there is no provision for post-Honours training leading to any Master's degree examination in this University. The M.Sc. degree in Statistics has been only a research degree throughout. The Annamalai University created a Department of Statistics in 1954 and a B.Sc. (Hons.) course in Statistics similar to the course offered by the Mysore University was introduced in the following year. Although there are Honours or post-graduate courses in five southern universities, still the total turnover, as could be seen from the details given later, is very small.

Among the South Indian universities, Madras is the only University providing a Diploma Course in Statistics. This is a two-year post-graduate part-time course conducted by the Department of Statistics of the University. This course was introduced in 1941 along with the formation of a single teacher department of Statistics by withdrawing the Lecturer in Statistics from the Department of Economics. Statistics is also offered as a subject for the Diploma Courses in Economics and Business Management, which are also part-time courses conducted by the corresponding Departments of the University.

The variations observed in the organisation of the Degree (Pass and Honours) and post-graduate courses have a significant bearing on the nature of researches and the turnover of research scholars taking research degrees among universities in South India. While the Osmania and Sri Venkateswara Universities have no facilities for higher teaching and research in Statistics, all other universities, except Madras, created fully integrated complete Departments of Statistics entrusted with the task of conducting Honours and post-graduate courses and research, providing adequate scope for developing research in theoretical and applied branches.

In Madras, research work in Statistics was entrusted to the Lecturer in Statistics who was appointed first in the Department of Economics and later as an independent department of study and research. Research workers are admitted regularly under supervision of the Head of the Department. The theses accepted for research degrees contain a study of some problem in methodology with empirical work associated with its applications.. In addition, work on mathematical aspects of Statistics was also conducted by professors of mathematics of colleges where Statistics is being taught at the Honours level. All the students that have been awarded research degrees so far are those that have taken Honours or post-graduate degree in Mathematics with Statistics for their degree or in any other post-graduate course.

From the information made available it appears as if research work is limited to members of the staff in most universities. So far the turnover of research scholars that have taken research degrees are only from Kerala and Madras Universities. However, it should be noted that considerable amount of work in the nature of assisting in planning of sample studies and analysis and interpretation of collected data is being undertaken by Statistics Departments that cannot take the shape of publications nor can be utilized for preparing theses for research degrees.

A detailed account of the activities of Statistics Departments are given later separately for each University. In this connection it should be noted that although the facilities for higher education are not fully developed and even those made available came into existence only recently, South India has contributed a fairly large number of distinguished workers in Statistics occupying important positions throughout the country. Even during this short period of over a decade since Statistics gained an independent position in the Science Congress, this section had five presidents that can be claimed by the universities of South India, namely, Prof. K. B.

Madhava who was the Professor of Statistics of Mysore University, Dr. N. S. R. Sastry who was Lecturer in Statistics, University of Madras, Dr. U. S. Nair, Professor of Statistics, Travancore University, Dr. K. R. Nair who was research scholar in Statistics, University of Madras, and Dr. K. Nagabushanam, Professor of Statistics, Andhra University.

All the four States in South India have separate and well developed Departments of Statistics. India, particularly after independence taking to planned economic development of the country with the consequent expansion of the activities of the State, stressed the importance of collecting reliable factual information on different sectors of economic activity in the country. This resulted in a rapid expansion of the Statistics sections in each State, providing highly centralised Departments of Statistics for not only collecting and processing routine statistics made available by various departments of Government but also to undertake independent sample studies. Adequate statistical staff are provided throughout the districts and all factual information required for formulating schemes of development and also for evaluating the success of any measures and changes introduced is obtained through the Directors of Statistics.

Madras is the first among the South Indian States to appoint a Statistical Officer to collect and prepare some routine statistics. This formed the nucleus for the gradual expansion and there are at present over one hundred employees, associated with the central organisation headed by the Director of Statistics. Kerala also has a highly centralized Statistical Bureau similar to the one in Madras but the activities of this section cover all aspects even including the taking of population census. Further, there is a very good coordination in the activities of the State Bureau and the Division of Statistics of the University. This has been very helpful in providing practical and professional training for the students taking post-graduate course in Statistics and also undertake some semi-academic sample studies on interesting problems. This is due to the fact that the Professor of Statistics of the University has been the Director of the Bureau of Statistics of the State and he was also the Superintendent for census operations. Andhra and Mysore States have also similar organizations and these are still being reorganised consequent on the recent changes made in the States. The details of the activities of the three of the

States Bureaux are provided in this section. It has not been possible to get details about Mysore State Statistical Organisation.

The University of Madras (1857), being the oldest among South Indian universities, has a pattern different from all other universities in this region. This being primarily an affiliating university, had to depend, for the starting of new degree courses, on the colleges seeking affiliation. The departments for research and study of the university are of comparatively recent origin. Though the work associated with these departments varies considerably, still the general approach has been to entrust these divisions with research and conduct of the Diploma courses. However, in recent years some teaching assistance is being provided for the Honours and post-graduate courses offered by colleges through the inter-collegiate schemes.

Statistics was first introduced as a subject for special study for the B.A. (Hons.) degree in Mathematics in 1920 by the Madras Christian College. This was immediately followed by the Pachaiyappa's College and later by the St. Joseph's College, Tiruchirapalli. These three institutions continue to train students taking the B.A. (Hons.) and M.A. degree courses in Mathematics with Statistics as a special subject and, on an average, about 80 students take these degrees every year. The content of this course remained almost the same but for minor alterations made recently in the direction of adding some current topics. Along with the introduction of Statistics for Honours course in Mathematics, this subject was included as a special subject for the degree course in Mathematics. This course is offered by a large number of colleges and about 300 candidates take this examination every year.

Following the provision made for the study of Statistics as a main subject in B.A. and B.Sc. (Pass and Honours) courses in 1940, three affiliated colleges located in different parts of the University have introduced the B.A. course and are continuing to provide instruction in this main degree course. On an average about 50 students take this degree every year. An attempt was made by a college in the Madras City to offer B.Sc. degree with Statistics as main subject but gave it up after sending two batches in the late forties.

It was only in July 1949 the Presidency College, Madras, secured affiliation and started the B.Sc. (Hons.) course in Statistics admitting a batch of 9 students. The entire work associated with conducting of this course has been entrusted to the Department of Mathematics of this institution. The content of this B.Sc. (Hons.) course is different from similar courses offered by other universities. While Statistics courses have been independent from Mathematics courses in other universities, the Pure Mathematics syllabus of this course covering three papers for the Honours examination is common with the Mathematics Honours course in this university. This provision has been helpful in conducting Statistics Honours course by the Mathematics Department, as it is possible to arrange for some combined classes. This course is being offered by only one institution, Presidency College, and so far six batches of students have been sent up for examination. The turnover of students that have taken this degree is given below:

Year	1952	1953	1954	1955	1956	1957
No. that took B.Sc. (Hons.) Degree	9	9	9	10	11	11

Though it is possible to admit students for post-graduate studies, so far no one has been admitted for this course in this institution. Among the staff of the Department of Mathematics of this college three possess qualifications in Statistics. There is no separate course of M.Sc. or any post-graduate degree course by examination available in this University. Taking into consideration the vast area that is being served by the University and also the growing importance of Statistics, the lack of facilities for post-graduate studies and the limited provision for admission to Honours course in Statistics have seriously restricted the scope of training students in main courses in this subject.

With the rapid recognition of the importance of Statistics in various branches of knowledge, this subject has been introduced for different degree and Honours courses. Since July 1953, Elements of Statistics is made a compulsory subject for a B.A. (Hons.) and M.A. degree courses in Economics and is being offered by all institutions having these courses. Elementary Statistics with reference to Education and Psychology forms a part of the Honours course in Psychology and degree course in Education. Similarly, some aspects of Statistics are introduced for courses in Commerce. In July 1954 the Government Arts College, Madras, started Statistics as a subsidiary subject to Mathematics and Physics degree courses. A course of Vital Statistics is given to the degree courses in Medicine, whereas a course on Statistics applied to Industry is provided for B.Sc. (Tech.) course in Textiles. The Diploma Course in Business Management, started in 1955 by the University, has included Statistics as one of the subjects of study. In general institutions offering these courses have been making their own arrangements for teaching these different courses in Statistics.

With the reorganisation of higher education and the introduction of three-year degree courses, Statistics is offered as a main, ancillary and also as a minor subject for science degrees. For studies in Humanities it is given a place in Economics and Psychology degree courses. Elements of Statistics is also introduced as a non-examination subject for the pre-professional courses for medicine, agriculture and veterinary science.

Statistics was first introduced at the University level in the Department of Economics. In 1929 the Diploma course in Economics that was being conducted by the University was revised and Statistical Methods was introduced as a subject for study. These new regulations that were brought into force from 1930 led to the creation of the post of Lecturer in Statistics in the Department of Economics from 1st July 1930. He was appointed to work under the direction of the Head of the Department of Economics to deliver lectures, conduct classes and engage in research and assist in any other academic work relating to the Department of Economics. Along with the provision for the study of Statistics at the degree level, it was decided in 1940 to institute a Diploma course in Statistics at the University. These changes presented the administrative difficulty of fixing the department of studies to which Statistics should be assigned and this situation led to the creation of a separate Department of study and research in Statistics in the faculty of Science. Thus, in 1941, the post of Lecturer was separated from the Department of Economics and the Lecturer constituted the new Department. This Department remained with a single lecturer till the end of 1952. In January 1953 the Lecturer, under the scheme of rotating Readerships, was made Reader and, based on the grant from the Government of India a Lecturer was added to the Department later in the same year. Again from January 1957 the Reader is promoted as Professor and at present the Department is made up of a Professor and a Lecturer.

The work of the Department of Statistics in the university falls under three broad categories, namely, (i) teaching, (ii) assisting in designing of scientific experiments and planning investigations and in the analysis of collected data and interpretation of the results, and (iii) conducting and guiding research.

Ever since the creation of the post of Lecturer in the Department of Economics, emphasis has been placed on the teaching aspect of his duties. This was the natural consequence of the circumstances under which the post was originally sanctioned. With the formation of the Department in 1941 and the institution of the Diploma course in Statistics, he was entrusted with the responsibility of conducting the course in addition to the usual teaching work for the Diploma in Economics. This Diploma course in Statistics is of two years duration and is conducted in the evenings as a part-time course open to any degree holder with Mathematics at the intermediate level. This course, ever since its inception, has been very popular and at present about 35 students are admitted every year. With the formation of a separate Department, the Lecturer commenced inter-collegiate lectures for students taking Mathematics Honours course with Statistics as a special subject. These lectures gradually became a part of the work of the Department and have been extended in recent years to the Statistics and Economics courses also. During 1948-50 the Lecturer taught Statistical Methods applied to industry for technology courses. The addition of a lecturer since 1953 provided some relief in the teaching work of the Professor for the Diploma course in Statistics. In addition to these, the Professor delivers special lectures in Statistics for research scholars in science subjects and a course of lectures on Statistical Methods applied to social science research to research workers under the Ford Foundation schemes.

Providing assistance in the academic work of the Department of Economics was the second aspect that was given prominence from the beginning. This statistical assistance that usually took the shape of analysis of collected data and interpretation of the results was confined mainly to the field of Economics during the early period. With the formation of a separate Department of Statistics this assistance was also sought by workers from other departments of study and research. The gradual recognition of the need for using Statistics in various branches of scientific studies resulted in a phenomenal increase in the work of the Professor. He has been giving assistance in designing experiments and in the analysis of collected data including interpretation of results for research workers in various branches of studies. Though this work has increased considerably, it cannot take the shape of research papers of the Department.

The third category of work, namely, conducting and guiding research formed always an integral part of the activities of the Head of the Department. Research workers were being admitted ever since the post of the Lecturer was first created in the Department of Economics and they work under the guidance and supervision of the Head of the Department. All research scholars admitted normally possess good qualifications in Mathematics and Statistical Methods and they work for the research degrees, M.Sc. or Ph.D. Some of them also conduct researches without proceeding for any research degree and submit a report of the work at the end of the period. On the whole, so far eighteen research scholars worked in the Department and nine of them were awarded research degrees and two are awaiting the result of the theses submitted by them. One of them being a research fellow on exchange from France completed his work and submitted a report. At present two scholars are working for the Ph.D. degree. Among the staff of the Department the research work is confined only to the Head of the Department. Some researches in problems of Mathematical Statistics were conducted by Professors of Mathematics of colleges teaching Statistics for Honours course and published as papers. A complete list of papers and books published and titles of theses accepted for research degrees are given elsewhere.*

Since 1951 the facilities for research and teaching in the Department have been considerably improved with the help of grants received from the Government of India and the University Grants Commission. These have been in three different directions. Firstly, providing funds for purchase of equipment, like calculators and tables and of books. In this direction so far Rs. 4,500 in 1952-53 and Rs. 7,500 in 1956-57 have been received. In addition, some part of the amounts made available for improving the University Library has been utilised to strengthen the Statistics section of the library. The second has been in the direction of sanctioning research scholarships. In addition to one University studentship, originally four Government of India scholarships (two Junior and two Senior) were allotted for this Department. Consequent on abolition of the Junior scholarship there are two Senior scholarships tenable in the Department. The third aspect is that of increasing the staff of the Department. With the recurring grants of Rs.4,200 made in 1953 it was possible to add the post of a Lecturer in 1953 to the Department that had only one staff member for two decades, making the present strength of two.

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*Please see the Journal of Madras University, Section B, Centenary Number (January 1957), pp. 96-98.

Various aspects of studies that have been undertaken by the Department can be broadly classified into two categories, methodological and applied. The close association of Statistics as a part of the Department of Economics for over a decade influenced considerably the choice of topics for research work. Applied problems that require collection and analysis of data and the interpretation of these results, particularly selected from the field of Economics, received greater emphasis. Even here the early investigations were based on data collected from the sector of Agricultural Economics. Besides a number of articles, two booklets were prepared. Though emphasis continued to be on the applied work, even after the formation of a separate Department of Statistics, there was a steady shift in the choice of subjects. Topics were selected from aspects of trade, industry and prices. Number of papers published during the forties are based on these studies. Equally important has been the gradual widening of the scope in the choice of topics for study to include various branches of knowledge, like Biology, Education and Demography, besides Economics. This expansion of work that resulted in a number of publications has been accentuated by the steady increase in the statistical assistance given to research workers in various branches of studies.

During the last decade these applied studies gradually shaped into two distinct branches of work. Current problems that involve statistical analysis of data and interpretation of the results form one branch. Under this category, choice of the topic for study can be from any branch of knowledge and the investigations usually lead to the preparation of a paper. This continues to be one of the aspects of work of the Department.

The other category of applied work related to empirical studies on observational data with the specific purpose of illustrating or providing verification of the results obtained on methodological problems. These studies often also help fundamental work on methodology. One important branch of studies undertaken in this category has been analysis of time-series. Commencing with the analysis of observational time-series, a number of investigations have been undertaken on the methodological aspects of the analysis and published as papers. This branch of theoretical work has been further pursued considering time-series as a particular aspect of stochastic processes. The study of some aspects of stochastic processes is one of the important branches of methodological work that is being undertaken by the Department. In this emphasis is laid on the problems of specification and inference of suitable stochastic model along with the necessary empirical analysis of real or artificial data.

Work based on problems on methodology selected from the general branch of sampling distribution formed a part of the studies undertaken by the Department from the very beginning. Problems on correlation were taken first and later these studies extended to distribution associated with different test criteria. Study of samples drawn from normal and non-normal universes including some aspects of testing of statistical hypotheses continues to be a fundamental aspect on which work is in progress. Most of the results have been included as parts of theses submitted for research degrees and published as papers.

Another aspect of work recently introduced as a part of the activities of the Department is that of planning and conducting sample investigations. These have been designed to provide adequate practical experience and also serve as applied work on sampling techniques for research workers. The data collected will be analysed and published as applied work. With the growing importance of Statistics, considerable expansion of all the activities detailed above can be expected in the Department.

It can be noted that Dr. Sastry, who was the Lecturer in Statistics during 1934-41, and Dr. K. R. Nair who was research scholar in the Department during 1933-35, were Presidents of Statistics section of the Science Congress.

The Mysore University, Mysore (1916), is the first among the universities in South India to give adequate recognition to Statistics as a separate branch of scientific knowledge by providing the post of Professor of Statistics and Mathematical Economics as early as 1923. For a period of six years Statistics and Mathematical Economics were taught to the B.A. degree in Mathematics and the M.A. degree courses in Mathematics and Economics. It was in 1929, when the Honours courses were introduced, that Statistics along with Mathematical Economics and Actuarial Science were included for the B.A. (Hons.) course in Mathematics and later for the one-year post-Honours M.A. course in Mathematics. With the complete reorganisation of courses in 1942, the B.Sc. (Hons.) course in Statistics and, along with it, the one-year post-Honours course of M.Sc. in Statistics, replaced the previous B.A. (Hons.) and M.A. courses. In addition to these main courses, Statistics forms an optional subject for the B.Sc. degree courses in Mathematics, Economics, Psychology and Physics. In 1950 a separate Department of Statistics was established. During the last six years the number of students completing the Honours and the M.Sc. degree courses average about 20 every year.

During 1955-56 a pilot sample survey 'On Consumers' Demand for Products of Cottage Industries in Mysore City was conducted by the M.Sc. students with a grant made for the same by the Indian Statistical Institute, Calcutta, through its Mysore State Branch. The members of staff of the department have published some research papers and books on some aspects of applied Statistics, sampling methods and industrial statistics. Four students have registered for the Ph.D. degree and so far no research degree has been awarded. Prof. K. B. Madhava who was the Professor of Statistics till 1949 was the President of the Statistics section of the Science Congress.

The University Grants Commission made a special grant of Rs. 22,000 during 1955-56 to the Department under the first and second Five Year Plans. This grant was utilised to increase the equipment of the laboratory by purchasing calculating machines and statistical tables.

At present, the Department of Statistics, located in the Maharaja's College, Mysore, has one Professor, two Assistant Professors and five Lecturers, besides one Assistant Professor who is on foreign service under UNESCO. The staff of the Department undertakes the entire work associated with conducting the B.Sc. (Hons.) and M.Sc. courses in Statistics, and the teaching of subsidiary courses in Statistics for degree classes.

The Osmania University, Hyderabad (1918), has a well developed department of Mathematics established in 1922. But Statistics has not been given any independent position except to provide it as one of the subjects for study for the degree course. The teaching work for this is undertaken by the Department of Mathematics by one of the Lecturers who is qualified in Statistics. So far facilities for degree or post-graduate courses and research work in Statistics are not provided in this University.

The Andhra University, Waltair (1926), being an affiliating and teaching university, provided for Statistics as a subject of study for the B.A. degree in Mathematics as it existed at the time of the formation of the University in some of the colleges of the Madras University. Subsequently, this subject has been introduced in B.A. (Hons.) courses in Mathematics and Economics conducted by the University. After training one of the staff members of the Mathematics Department in Advanced Statistics, the University created a separate Department of Statistics in 1951. This new Department was entrusted in the same year with the responsibility of training students for the M.Sc. degree in Statistics by examination. This course extends over two years and admission is restricted to students that have already taken the B A. (Hons.) degree in Mathematics or in Economics. This course, like all Honours and post-graduate courses, is conducted only in the University. Statistics as a special subject is offered for the degree courses in Mathematics by many colleges affiliated to the University. The number of students admitted for the M.Sc. course has been varying and average to about 10 every year.

The theoretical researches carried out relate mostly to the theory of stationary random processes. Some aspects pertaining to the necessary and sufficient conditions for existence of a stationary process satisfying a given linear relationship with another process and to the problem of inversion, estimation of the mean value, and prediction formed the thesis prepared by the Professor during the period of his training out of India and published in 1951 under the title 'The Primary Process of a Smoothing Relation'. Further work on this branch relates to the fixing of unbiassed minimum variance estimates, of the mean value of a descrete process and constructing consistent estimate of the spectum of a stationary process at point of its continuity. Two papers are published on these aspects.

Some problems on application of statistics to data on current economic problems have been studied. These are prepared as papers and three of them are published.

Based on schemes sanctioned by the Research Programmes Committee of the Planning Commission, two important projects have been completed and reports submitted, namely, on 'Urbanisation of Vizagapatam' and 'Household budgets of the port and shipyard workers of Vizagapatam'. This work was undertaken jointly with the Department of Economics under the direction of the Professor of Statistics.

The Professor was also the sectional President of the Science Congress session, January 1956, and his presidential address was on 'Inference in Time-Series'.

During the short period of about six years, the Department expanded rapidly. There are at present eight members on the staff. Besides the Professor, two other members had the benefit of advanced training in Statistical Methodology with special reference to applications in Economics. The research work appears to be confined mainly to the staff of the Department.

In addition to the work associated with the M.Sc. course in Statistics and training students in Statistics for the Mathematics and Economics Honours courses and their own research work, the staff provides the necessary assistance in planning and designing of experiments and in the analysis and interpretation of data of research workers of different departments.

Annamalai University, Annamalainagar (*South India*) (1929) introduced Statistics as a subject for study first for the B.A. (Hons.) course in Mathematics. Taking into consideration the growing importance of Statistics, a separate department of study was instituted for this subject with the appointment of a Professor of Statistics in July 1954. Simultaneously a two-year B.A. degree course with Statistics main and Economics as a subsidiary subject was introduced. In the following year, commencing from July 1955, the three-year B.Sc. (Hons.) course in Statistics was started and the first batch will be completing the course in March 1958. About 20 students are being admitted every year for the Honours course and 15 for the degree course. Two batches have so far taken the B.A. degree (Statistics main) examination and the turnover has been 6 and 8 students in these two years 1956 and

1957 respectively. In addition, Statistics is also offered as a subject of study for B.A. (Hons.) in Economics and M.Sc. in Agriculture.

With the grants made by the University Grants Commission to the tune of Rs. 10,000 it has been possible to build a good library and also provide equipment for this section. The Government of India sanctioned one research scholarship in 1956. The recipient of it conducted a pilot sample survey relating to the size and conditions of families of students who are admitted to the Annamalai University. He has been absorbed as a Lecturer in the Department since the commencement of the academic year 1957.

The Department has at present a Professor and three Lecturers. The entire work associated with conducting the B.A. and B.Sc. (Hons.) Statistics courses and teaching Statistics for the B.A. (Hons.) Economics and M.Sc. (Agriculture) is undertaken by the staff of this Department.

The University of Kerala (August 1957) was formerly Travancore University, Trivandrum (1937). When the Travancore University was instituted in 1937, Statistics was included as one of the special subjects for the Mathematics Honours and Degree courses. In 1939 one of the Assistant Professors in the Department of Mathematics returned after advanced training in Statistics and this has led to some students joining the Department for research work in Statistics. During the period 1933-44, research workers in Statistics attached to the Department of Mathematics were attending to the work of various schemes in the Government and the Central Research Institute in which statistical techniques had to be adopted.

In view of the increasing usefulness and appreciation of statistical techniques and research, the Director of Research, Central Research Institute of the University, forwarded proposals in October 1944 for the organisation of a Statistical Laboratory and Bureau of Statistics in the Institute and the institution of a course of studies in Statistics leading to the M.Sc. degree in Statistics. These proposals were enforced and the Division of Statistics under the Central Research Institute started functioning from that year. The responsibility of teaching post-graduate students in Statistics leading to the M.Sc. degree covering a period of two years was entrusted to this division from 1945. This two-year M.Sc. course in Statistics, started in 1945, is the first complete post-graduate course in Statistics introduced in any of the South Indian universities. This M.Sc. resembles the post-graduate course in different subjects existing in a number of north Indian universities. Admission for this course is restricted to graduates in Mathematics, Statistics and Physics (with Mathematics subsidiary). The aim of this course is to impart a good knowledge of theoretical Statistics and training in field work in Agricultural Statistics and sample surveys. The syllabus of the M.Sc. course is flexible to provide for changes that are in line with recent advances in the subject. Regular practicals form an important feature of the course and the students are given facilities for field work in sample surveys under the supervision of the State Department of Statistics. The folowing table gives the number of students that qualified for the M.Sc. degree in different years.

Year	No. qualified for M.Sc. degree by examination
1946-47	6
1947-48	8
1948-49	8
1949-50	9
1950-51	10
1951-52	11
1952-53	12
1953-54	11
1954-55	12
1955-56	15
1956-57	14

Besides the M.Sc. degree a three-year degree course in Statistics was started in 1948 but it had to be temporarily suspended in 1951. Statistics is offered as a subject of study for the honours and post-graduate courses in Mathematics, Economics and for the degree course in Agriculture and Medicine. In addition this subject is offered for special studies for the graduate courses in Mathematics in most of the affiliated colleges of the University. From 1957 the three-year degree course is again introduced in some of the affiliated colleges.

The University provides facilities for research leading to M.Sc. and Ph.D. degrees by thesis. So far two took the M.Sc. degree by research and one took the Ph.D. degree.

The main subjects on which researches are being conducted in this section may be classified under five topics: (1) Sampling Distributions, (2) Tests of Hypotheses, (3) Design of Experiments, (4) Demography and (5) Miscellaneous applied statistical methods. A large number of papers have been published on different branches covering most aspects of Statistical Methodology by the staff and research workers of the Department. The Professor as Superintendent, Census Operations, for the State, was associated with the population census and some results are analysed and published as a volume entitled 'Sampling Studies—Census of India, 1951' by the Government of India. Dr. U. S. Nair, the Professor of Statistics, was the sectional President of the Indian Science Congress in 1947.

The division of Statistics has one Professor and four research officers who attend to the teaching and research activities of the Department. During the period 1955-56 two members of the staff had advanced studies in United States of America. Besides conducting the M.Sc. course in Statistics, the Department of Statistics is responsible for teaching the subject for Honours and post-graduate courses in Mathematics and Economics of the University College, Trivandrum. In addition, the Professor gives about 15 to 20 lectures every year to the final year students of the Medical College. He is also the supervisory teacher to all the research scholars and research students of the department. In addition to teaching and research, the staff of the Department attend to the planning and lay out of field work and other experiments in the various departments of the research institute and Government research stations. The analysis of the data from these experiments is done by the staff of the Department.

The Government of India and the University Grants Commission sanctioned the following grants for the purchase of books and equipments required for this Department.

Year	Amount in Rs.
1950-51	4,000
1953-54	13,000
1955-56	12,500
1956-57	10,000

The Department is provided with a well equipped laboratory containing calculators, tables, etc., and a good sectional library with books and periodicals. In 1956 an allotment of $2,000 has been made available from the Wheat Loan Fund for the purchase of books and periodicals for the Department.

The Karnatak University, Dharwar (1950) created the Department of Statistics by appointing a Professor of Statistics in September 1951. The post-graduate M.A. and M.Sc. course in Statistics was started in June 1952 and so far four batches have taken the examination. Consequent on the Professor leaving the services of the University in August 1952, the Department has been allowed to function without a Professor. The M.A. and M.Sc. course is of two years duration and the students devote nine hours per week to practical experiments selected from various important fields of application of Statistics in agriculture and industry and nine hours per week to lectures in theoretical Statistics. The following table gives the number of students that passed in M.A./M.Sc. Statistics in different years.

Year	1954	1955	1956	1957
No. of students	4	8	9	18

So far research work is confined to the staff members and no research student is admitted. The important line of research has been in the theory of sample surveys and its applications and so far six papers have been published by the Reader, who is the Head of the Department in this branch. Work on some aspects of testing of statistical hypotheses is also being undertaken and some papers are published on this topic by the staff members.

The University Library maintains a good collection of periodicals and books suitable for higher teaching and research work. There are four members on the staff, one Reader, two Lecturers and one Demonstrator, besides another Reader who is on leave for higher studies abroad.

Sri Venkateswara University, Tirupati (1954) has not introduced Statistics so far, as a subject of study either for honours or post-graduate courses. The University is an affiliating and also a teaching University. It has no separate department of Statistics and no research is contemplated in this subject. However, Statistics is retained as one of the two special subjects of study for the B.A. degree course in Mathematics as it existed at the time of formation of this University in Madras and Andhra Universities. This course is offered in some of the affiliated colleges. In the new scheme of three-year degree courses, Statistics and Astronomy are put together as one compulsory special subject for the degree course in Mathematics.

The Department of Statistics, Madras State, came into existence as a natural growth of the organisation for Statistics which has been evolving through various stages during the last three decades. Originally, the Statistical Unit comprised of a small section in the permanent set up of the Board of Revenue under the charge of a Deputy Collector designated as 'Statistical Assistant'. That Unit was dealing mainly with agricultural statistics compiled through the Revenue agency. It was in 1933 that a fully qualified statistician, who was then the Lecturer in Statistics of the University of Madras, was appointed as Statistical Officer to take charge of statistical work in the Office of the Board of Revenue. The activities of the Department expanded soon into the sphere of prices, commerce and industries. In 1942, it was entrusted with the additional work of dealing with statistical problems arising in the Civil Supplies Department and in the introduction of controls. With the creation of the post of Economic Adviser to Government in 1948, this organisation was transferred from the Board's office to work under the Economic Adviser as a unit attached to the Public Department. In October 1953, the Office of the Economic Adviser was reorganised into the Department of Statistics with the Director of Statistics as the Head of the Department.

The Department of Statistics is concerned with the collection, analysis, interpretation and publication of statistics relating to various sectors of the State economy like Agriculture, Livestock, Industry, Trade, Prices and Wages. Special enquiries are also undertaken from time to time at the instance of the State Government, Central Government and the Indian Central Cotton Committee. The Department deals with statistical work relating to Community Development and Planning in general.

Under the Second Five Year Plan, the Department has undertaken a comprehensive programme of work for the development of Statistics. Statistical Units are being set up in the districts under District Statistical Officers.

Work relating to Agricultural Statistics consists of issuing periodical forecast reports on 26 important food and commercial crops, framing 'ad-hoc' estimates of area and production of crops not covered by forecast reports, compiling the 'Return of Agricultural Statistics' to serve the needs of All India Report, conducting crop sampling surveys on paddy and principal millets to estimate their outturn in an objective manner, compiling monthly and annual rainfall statistics and publishing the annual Season and Crop Report dealing with agricultural facts and figures. The Season and Crop Report is the principal annual publication of the Madras Government giving detailed district-wise statistics in regard to classification of area, area and yield of crops, area irrigated, rainfall, agricultural wages, prices of agricultural commodities, etc.

Collection of wholesale and retail prices of important commodities at select centres in the State, compilation of weekly cost of living index for working classes in the Madras City and in five moffusil urban centres and in eight rural centres, compilation of index numbers of wholesale prices of foodgrains and commercial products and collection of farm (harvest) prices for principal crops in the different districts in the State are some of the main items of work relating to price statistics. Under trade statistics, statistics of foreign, coast-wise and rail-borne trade relating to important commodities are collected and index numbers of import and export prices are compiled.

Work relating to Industrial Statistics consists of collection and compilation of annual statistics relating to capital invested, wages paid to workers, raw materials consumed, quantities of finished products manufactured, value of output etc. from factories using power and employing twenty or more workers and coming under the first 29 industries listed in the Census of Manufacturing Industries, rules and quarterly statistics relating to attendance, earnings, etc. of industrial quarterly statistics relating to attendance, earnings, etc. of industrial workers employed in factories and in plantations in the State.

Statistical work relating to Community Development in the State comprises of items like preparation of periodical reviews on the principal achievements in the Community Development areas, quarterly block-wise statements of cumulative achievements, statements showing the staff in position in the Community Development Blocks and National Extension Service Blocks, compilation of index numbers for assessing the over-all achievements of the Blocks, preparation of detailed review comparing the

State's achievements with other States and compilation of the Annual Administration Report of the Rural Development Project Department.

The Department has so far undertaken 12 different surveys and a variety of schemes under sixteen topics are included for implementation during the second Five Year Plan period.

The staff of the Department include district officers and a large number of investigators in addition to the headquarters office with a Director, two Statistical Officers, six Assistant Statistical Officers and about 100 other assistants in technical and administrative work.

The Department of Statistics, Kerala State, was formed in September 1954 to provide uniformity of procedure and gain efficiency in the work of collection of statistics in the State that was being attended by different Departments.

Besides collection and compilation of routine statistics, the Department has undertaken a large variety of census and sample surveys. The land census, live-stock census and a census of handlooms, have been completed and reports prepared. A sample survey of unemployment, a study of origin-destination survey in some major towns to assess transport problems and pepper survey have also been completed. Studies in survey of cultivable waste lands is in progress. In addition, crop estimation surveys are being undertaken for preparing crop forecasts. The department also undertakes collection and publication of price and vital statistics.

This Department has undertaken the work relating to the National Sample Survey as a part of an integrated sample survey. Two rounds of the survey were conducted in 1956-57. Very useful data on socio-economic issues like household income and expenditure, employment and unemployment position, vital statistics, building and repair activities, production and utilisation of live-stock products, etc., were collected. Information was also collected on land uses, prices of selected commodities and weights and measures in use in establishments.

Taking into consideration the requirements for evaluation of results of implementation of plan schemes, a small unit has been formed for quantitative assessment. For each project it is proposed to review every month the progress of work, both current and cumulative, under expenditure, physical progress and employment generated. A small unit to study national income for the State has been formed in the Planning Cell.

The Department has arranged for the publication of Statistical bulletins. The activities of the Department have been rapidly increasing and at present there is a complete statistical organisation extending to every district. On the whole, the Department has about 350 technical staff, and 55 administrative staff, beside a Director and three Assistant Directors. The expenditure during the recent three years 1954-55, 1955-56 and 1955-57 has been Rs. 1·22, 2·76 and 5·45 lakhs respectively.

The position of the State Statistical Bureau with the Division of Statistics is rather unique in that the Professor of Statistics of the University is also the Director of Statistics. This has helped considerably to coordinate activities by introducing new techniques and procedures for conducting surveys and in the collection and analysis of routine statistics, while it has been possible for the university students to get adequate practical training.

The Bureau of Economics and Statistics, Andhra Pradesh, Hyderabad, is formed in 1957 by putting together the staff allotted from the similar bureau existing in Hyderabad since April 1954 and the staff allotted to Andhra State at the time of its creation in 1954 and functioning in the Board of Revenue.

In Hyderabad an independent Statistical Department was set up as far back as 1919. This Department gradually developed into a highly centralised statistical organisation attached to the Revenue Secretariat covering the fields of Agriculture, Industry, Labour Prices, Cost of Living Indices, Education, Medical, Public Health, Banking, Trade, etc., as is evident from its periodical publications. In 1941 the Population Census work was entrusted to this Department but the next Census was conducted independently.

Meanwhile in 1947 an Economic Adviser's Office was created in the Finance Department to conduct Economic Enquiries and Research, to advise the Government on economic matters and to publish a periodical. It brought out a number of publications relating to the Rural Economy and the Finances of the State. The Statistics Department and the Economic Adviser's Office were amalgamated into the Bureau of Economics and Statistics in 1954. This Bureau had more than ten gazetted officers and 100 non-gazetted technical assistants and field staff. It was responsible for the conduct of annual agricultural and livestock census and crop cutting experiments on certain important crops. In the sphere of Industries and Labour, it was collecting, analysing and publishing, among other things, data relation to Production, Strikes, Employment, etc. The Primary Wholesale and Retail Price Collection was being done by the Bureau and, with the latter data, cost of living indices for six centres were being prepared. This office was also responsible for collecting different types of statistics from Departments like Education, Public Health, Medical, Police, Road Transport, etc., and these data along with other data were being published in the periodical issued by the Office and also in the annual Statistical Abstract. This Bureau under took some *ad hoc* work like Census of Government Employees and Survey of extra-factory Cotton Consumption for the Central Cotton Committee.

On the economic research side, the Bureau undertook researches on specific topics for the use of Government, like preparing Memoranda to the Taxation Enquiry Commission and Finance Commission. In addition to all this work, the Director was the ex-officio Superintendent of Census Operations in the State and the Bureau was dealing with considerable amount of post-Census work.

With the formation of Andhra Pradesh the Bureau has been attached to the Planning and Development Department. The Bureau of the new State continues to deal with all items of work for the whole State which the Hyderabad Bureau and the Andhra Statistical Branch were dealing with separately. Immediately after the formation of the new State, the statistical schemes under the Second Five Year Plan have been revised and a number of important schemes are to be implemented during the Second Plan period. These include socio-economic surveys, crop cutting experiments on non-food crops, survey of small-scale and cottage industries and setting up of a Planning Cell.

ZOOLOGY

Zoology as a subject of study was introduced in the curriculum of the University of Madras in 1882 and up to the early decades of the present century, the main emphasis has been on teaching. However during this period taxonomic studies received some attention due to the pioneering efforts of the successive Superintendents of the Madras Government Museum. One of the notable contributions has been that of Thurston on the 'Batrachians of South India' published in 1885 in the Bulletin of the Madras Museum, old series. Years later his successor, Dr. F. H. Gravely carried out extensive taxonomic work on the marine fauna of Krusadai island in the gulf of Manar and under his guidance a series of useful faunistic papers were published as Museum Bulletins. An important landmark in the growth of zoological research in South India, has been the decision of the University of Madras to start a Zoological research laboratory. In 1926 the Syndicate of the University appointed an expert committee which recommended that Madras by virtue of its location on the sea front has unique advantages for the pursuit of marine zoological researches and in the absence of facilities for research in any of the constituent colleges, a research laboratory of the University was long overdue. The function of such a laboratory would be to provide training in research and advance zoological knowledge. The committee felt that the laboratory should confine itself to research in pure science without deliberately aiming at knowledge of utilitarian value. These recommendations were accepted and in the following year the zoological research laboratory was started under the honorary directorship of Sir K. Ramunni Menon. In 1930 through a generous building grant made by the Government of Madras, the foundation stone of the present building was laid and three years later it was completed and occupied. Prof. R. Gopala Iyer who succeeded Sir K. R. Menon in 1929 was made full time Director.

The early work in the laboratory from 1927 to 1933 was of preliminary nature and necessarily so for the field was still virgin and with a few exceptions little or nothing was known at that time, of the fauna of Madras. Naturally the work undertaken was mainly taxonomic and anatomical. The publications during this period dealt with descriptive accounts of polychaete larva, Scyphomadusae, Hydromedusae of Madras. Plankton studies occupied an important place in the scheme of work. A plankton calendar was prepared giving a list of the more common organisms occurring in different months of the year. This was followed by an account of the Madras inshore plankton, and studies on the larval history of the common decapods of Madras. Besides a series of anatomical studies on the more common animal types were commenced.

With the occupation of the new laboratory buildings in 1933 a scheme of work was drawn up by the then Director which is itself of interest as indicating the lines along which the research work of the laboratory was developing. Alongside of studies already being pursued, fresh lines of investigation were also started. The ecology of the brackish waters of Madras received early attention. It is obvious that any scheme of studies on marine fauna cannot be limited to the inhabitants of the sea for marine animals invade estuaries and backwaters. It is well known that tropical conditions favour such inward migration. The studies on the brackish water fauna while revealing its predominantly marine character, show interesting features of adaptation to life in an environment that is markedly fluctuating, posing a number of problems for further study. Other lines of development were in regard to structure and life-history of parasitic protozoans, cytological investigations in relation to structure and role of cytoplasmic inclusions. Although the bulk of work during the early period followed traditional lines of pure research, occasionally investigations were taken up which show an obvious utilitarian value indicative of future trends. Such for example was the study of the food and feeding habits of perches and the age determination of fishes of Madras.

In 1938 the research work of the laboratory was reviewed by a committee under the chairmanship of Dr. Seymore Sewell F.R.S. The commitee felt that the absence of hydrological studies was a serious gap in the scheme of work of the laboratory. One could see how important such studies are for gaining an understanding of the sea as a biological environment, so necessary for the elucidation of many problems bearing on the adaptations of marine organisms to changing conditions of life in the sea. It is important to possess knowledge of the physics and chemistry of sea water and their bearing on the growth and abundance of phytoplankton which in turn affects planktonic organisms on which the larger forms of life including fishes have to depend for their food either directly or indirectly. The committee recommended that "facilities should be provided to research students to go to sea and obtain serial water samples and tow nettings at standard depths and thus be in a position to make more detailed study of various marine forms and the actual conditions under which they live".

The outbreak of the European war in 1939 had its repercussions in India. The recommendations for the improvement of the laboratory had to be shelved for the time being. However the war time economy brought in its wake many problems, one of the most urgent was the acute food shortage and the question of augmenting the food resources of the country. An immediate effect, so far as the laboratory was concerned, was the subsidizing by the Government of India of new schemes having a bearing on food production such as study of fish eggs and larvae, the biology of prawns of Madras. In general fishery biology received a fillip. During this period Prof. R. Gopala Iyer retired from service and was succeeded by Dr. N. K. Panikkar in 1944. Early in 1946 Dr. Panikkar left the laboratory and by the end of the same year the present Director, Dr. C. P. Gnanamuthu joined. The succeeding years witnessed many-sided improvements in the laboratory. The Government of India in addition to subsidizing special schemes of investigation, awarded scholarships tenable in the laboratory. In 1950 a special grant was made for the installation of sea water circulation in the laboratory to facilitate more advanced investigations of a physiological nature and for studies on the habits and behaviour of marine animals. More funds were available for newer equipment for specialized work. The permanent staff of the laboratory which up to 1950 consisted of only the Director and a research assistant was added to by the sanction of a post of Reader to which Dr. G. Krishnan was appointed. In 1953 another post of a lecturer was added. This was filled by Dr. S. Krishnaswami. The student strength rose to 15 which is the maximum that could be accommodated in the laboratory. In the research work of the laboratory a noticeable change may be seen in the subject matter of the investigations. While the earlier work on the anatomy and life-histories of common animal types was continued there has been a shift of emphasis on new lines of study. Fishery biology came to occupy a more important place in the scheme of work. A number of important papers on copepod parasites of fishes were published. In addition cestodes and trematodes parasitic on fishes received attention. The food and feeding habits of fish larvae were investigated by tracing the life-history of the more common fishes of Madras. With a view to assess the comparative food value of the edible fishes, an investigation of the fat contents of different species of fishes was carried out. Another important series of studies started during this period were in regard to fouling organisms. The wood preservation branch of the Forest Research Institute, Dehra Dun subsidized a scheme of investigation on the fouling organisms of the Madras Harbour. These studies resulted in an elucidation of the factors governing the settlement of the foulers. Such information is of value in making anti-fouling operations successful. Similar studies on the wood-boring molluscs yielded results on the peculiarities of the digestive mechanism of these forms enabling them to digest wood. Biological studies of this nature form a necessary preliminary to control measures for checking the damage caused by the organisms.

Alongside of studies which have a direct economic importance fundamental research has not been neglected. A notable advance was made in planktonic studies by diverting attention from qualitative work to quantitative estimations of planktonic organisms and fluctuations in their abundance were studied in relation to physical and chemical factors of sea water. In ecological studies a change over was made to the interstitial micro-fauna with reference to copepods and free living nematodes. Experimental studies have been conducted in relation to the respiratory mechanism of Amphibia and regeneration in ascidians. In keeping with modern trends in zoological research histochemical studies were started with reference to the cuticle of arthopods. The laboratory has been able to contribute to the advancement of this branch of knowledge by the studies the arachnid *Palamneus* in which it has been found for the first time that the mode of hardening of the cuticle is different from that obtaining in most other arthropods involving disulphide linkages similar to that seen in the vertebrate keratin. Subsequent work in the laboratory revealed that the above feature is not unique to Arachnida, and is found in Myriopoda and Pycnogonida as well. Another interesting feature brought to light is the occurrence of chitin in the arthropod epicuticle which has hitherto been believed to be non-chitinous.

In the last few years increasing attention has been paid to a study of the physiology of marine animals. The problems studied have been varied, such as osmoregulation, excretion and respiration of selected marine animals. So far more than two hundred papers emobodying the results of investigations carried out in this laboratory have been published in leading scientific journals both in India and abroad. The laboratory in addition to training students in research leading to Master's and Doctorate degrees, also conducts a course for the M.Sc. degree by examination. The laboratory is now being equipped for physiological studies of an advanced nature. Before long it is hoped that a number of schemes of physiological investigations would be pursued. The importance of such studies cannot be better expressed than in the words of Romanes that "in the invertebrates we see life in its simplest shape, and in the shape which best admitted of observation and experiment with the view of throwing light upon most of the great questions relating to the process of life". It is by progress in such new lines of study that the laboratory would be able to widen its sphere of usefulness in the years to come.

Although the colleges affiliated to the University of Madras are mainly engaged in teaching, contributions on the research side have also been made by some of them. The Presidency College, Madras, is a notable instance. The first Professor of Zoology, Dr. A. G. Bourne, who joined the college about the last decades of the last century gave an impetus to Zoological research by his own valuable contributions. In the earlier years the research activities were confined to the members of the staff. The subject matter of the studies show a wide range varying with the predelictions of the professor and the prevailing trends in research. A brilliant succession of professors following Dr. Bourne was responsible for the continuance of the research traditions of the college. Sir K. Ramunni Menon who succeeded Prof. Bourne was keenly interested in the anatomy and development of coelenterates. In 1927 Dr. S. G. Manavala Ramanujam was appointed to the chair of Zoology. During his tenure of professorship, in addition to the new B.Sc. and B.Sc. (Hons.) courses in Zoology, a research course leading to the M.Sc. degree was introduced in the college. The lines of study pursued were on morphology and anatomy of mammals, gastropods and helminths. At present the Government of India have sanctioned research scholarships tenable in the Zoology department of the college to students preparing for the M.Sc. and Ph.D. degrees. Recent work carried out in the department comprises taxonomical and ecological studies on the soil nematodes, Experimental work with special reference to host-parasite relationship of nematodes is also being carried out. The research students work under the guidance of the Professor H. Enoch.

The Madras Christian College, one of the oldest in the University, shares the pride of place with the Presidency College for outstanding contributions in the sphere of higher education in sciences. Ever since the introduction of Zoology in the University courses of study, it has been taught by this college up to the highest level leading to the degree of Master of Arts. That the college has proved a great success in teaching Zoology may be seen from the large number of its alumni who, in later life, made a mark as eminent Zoologists. From the time of Dr. Henderson, the first Professor of Zoology, the college has been served by a band of professors of merit who, by their own individual research contributions, have infused the research spirit in the students. At present the Head of the Department of Zoology is Dr. J. P. Joshua.

Zoological research with reference to its application to agriculture has been pursued since 1906 in the Agricultural College, Coimbatore, one of the professional colleges affiliated to the University of Madras. The research activities of the college received an emphasis under the able guidance of Dr. Fletcher who was appointed the first Government Entomologist in 1912. His work on the South Indian insects gave an impetus for research studies in entomology in South India. Since Fletcher's time, the department registered a steady progress due to the untiring efforts of successive entomologists like Dr. Ballard, Dr. T. V. Ramakrishna Iyer and others who followed. The present Entomologist guiding the research work of the department is Mr. Bashir. During the earlier years the research work of the department was necessarily confined to a survey of the insect fauna of South India and to building up a reference collection of insects. In the succeeding years attention was directed to a study of the bionomics of important crop pests and the methods of controlling them. Notable success has been achieved in pest control by the application of biological control measures, with reference to the black headed caterpillar of coconut and others. In recent years considerable progress has been made in this respect by the application of chemical methods. The department has contributed to the advancement of this branch of Zoology both on the pure and applied side and a number of research publications have been made on various aspects of agri cultural entomology.

In addition to teaching zoology and agricultural entomology for the under graduates preparing for the B.Sc., (Ag.) degree there is provision for post-graduate research courses leading to the M.Sc., and Ph.D. degrees in entomology. During the last 50 years the annual intake of the under-graduates has shown a steady rise from 20 students in 1920 to as many as 162 in 1956.

Contributions to our knowledge of the oligochaetes of Travancore have been made by the work carried out in the Maharaja's College, Trivandrum, during the twenties of the present century and when this institution was transformed into the University College with the formation of the University of Travancore in 1937, a fillip was given to the research activities by the starting of a marine biological institute. In addition to fishery biology the other lines of study pursued are on embryology of crustacea and arachnida, and neurosecretion in arthropods.

The Central College, Mysore, which is the principal institution of the Mysore University, has been a centre of Zoological research for a number of years. Under the guidance of the first Professor of Zoology, Prof. C. R. Narayana Rao, research studies were initiated on the taxonomy, morphology and development of Amphibia. He was succeeded in 1937 by Dr. A. Subba Rao whose main interest has been cytological studies bearing on oogenesis. In 1946 Dr. B. R. Seshachar succeeded to the professorship. Recent studies are on cytology, cranial osteology, etc. Alongside of these more modern branches of study have been pursued such as cytochemical investigations with reference to nucleic acids, enzyme action in ciliates and experimental work on the role of endocrine organs in fishes. In addition to teaching, training in research is being given to students preparing for the post-graduate research degrees.

The Annamalai University, which was started as a unitary residential University in 1929, has been concentrating on teaching of Zoology till 1947, when Honours and post-graduate research courses have been started. The laboratory is equipped for investigations on embryology and cytology. A biological station has recently been started at Porto Novo, about 10 miles from the University campus and is intended for pursuit of studies on estuarine ecology and hydrological investigations. The station possesses a research vessel 'Medusa' for carrying out hydrological and faunistic surveys. A number of important publications have appeared on work carried out by Professor R. V. Seshaiya or by others under his guidance. These refer to freshwater Polyzoa, parthenogensis and polyploidy in melanid snails, the controlling factors of aestivation metabolism of *Pila* and life-history studies of fluviatile Gastropods. There are at present five Government of India scholars working in the laboratory in addition to others pursuing research investigations for the M.Sc., and Ph.D. degrees of the University.

Andhra University, Waltair, is one of the early offsprings of Madras having been founded in 1926. But it was only in 1947 Zoology was introduced as a subject of study in the Honours and post-graduate research courses. The first professor of Zoology was Prof. R. Gopala Iyer and he was succeeded by Dr. P. N. Ganapathi in 1951. The principal topics of research are marine biological and parasitological. The location of the University close to the seashore has been taken advantage of for the studies on hydrology, and plankton. Another useful line of research pursued since 1954 is the biology of fouling organisms which cause damage to timber. This work has been sponsored by the Forest Research Institute, Dehra Dun. Parasitological studies include protozoan parasites in marine animals and others. Up to date more than 40 publications have been made by the staff and students of the department.

The Karnatak College, Dharwar, affiliated to Karnatak University, which is now included in the new Mysore State, provides research courses leading to the M.Sc. and Ph.D. courses. Under the guidance of the Professor of Zoology, Dr. K. R. Kharandikar, a number of research problems have been studied such as maturity and spawning periods in fishes and studies on protozoans.

In Sri Venkateswara University, Tirupati, which was started in 1954, there is provision for Honours and post-graduate courses in Zoology. Under the guidance of the Professor of Zoology and Principal of the University College, Dr. S. G. Manavala Ramanujam a vigorous policy designed to encourage Zoological research has been pursued from the very inception of the University. Recently post-graduate research course leading to the Master's degree has been started. In the scheme of work drawn up for research investigations emphasis has been laid on physiology. The members of the staff are actively engaged in research studies on such topics as respiration in poikilotherms, cuticle of arachnids, invertebrate neurophysiology. A survey of the local fauna is also receiving attention.

In addition to the work carried out in universities and colleges, valuable contributions to the advancement of zoological knowledge have been made by the departments of fisheries both of the Central and the State Governments. In 1947 the Government of India started a Central Marine Fisheries Research Station at Mandapam near the southern tip of the peninsula. The first chief research officer was Dr. H. S. Rao and he was succeeded by Dr. N. K. Panikker in 1950 who was mainly responsible for the building up of a biological laboratory on modern lines with all the equipment necessary for advanced research studies. The work carried out at the laboratory refers mainly to fishes and other marine organisms of economic importance, with a view to a more complete exploitation of the resources of the sea. At present the chief research officer is Dr. Jones. The department of Fisheries of the Madras State is the oldest in India and has been a pioneer in the field of fishery development. A number of valuable contributions have been made from time to time as a result of the research work of the successive Directors and their colleagues, which have helped to advance our knowledge of the fish and fisheries of the Indian seas.

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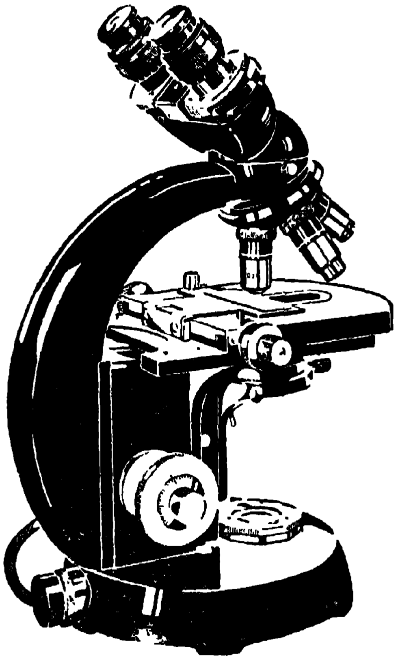

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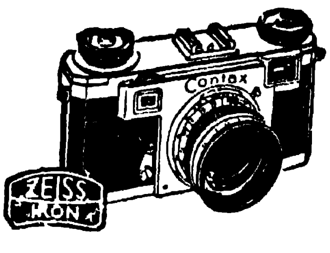

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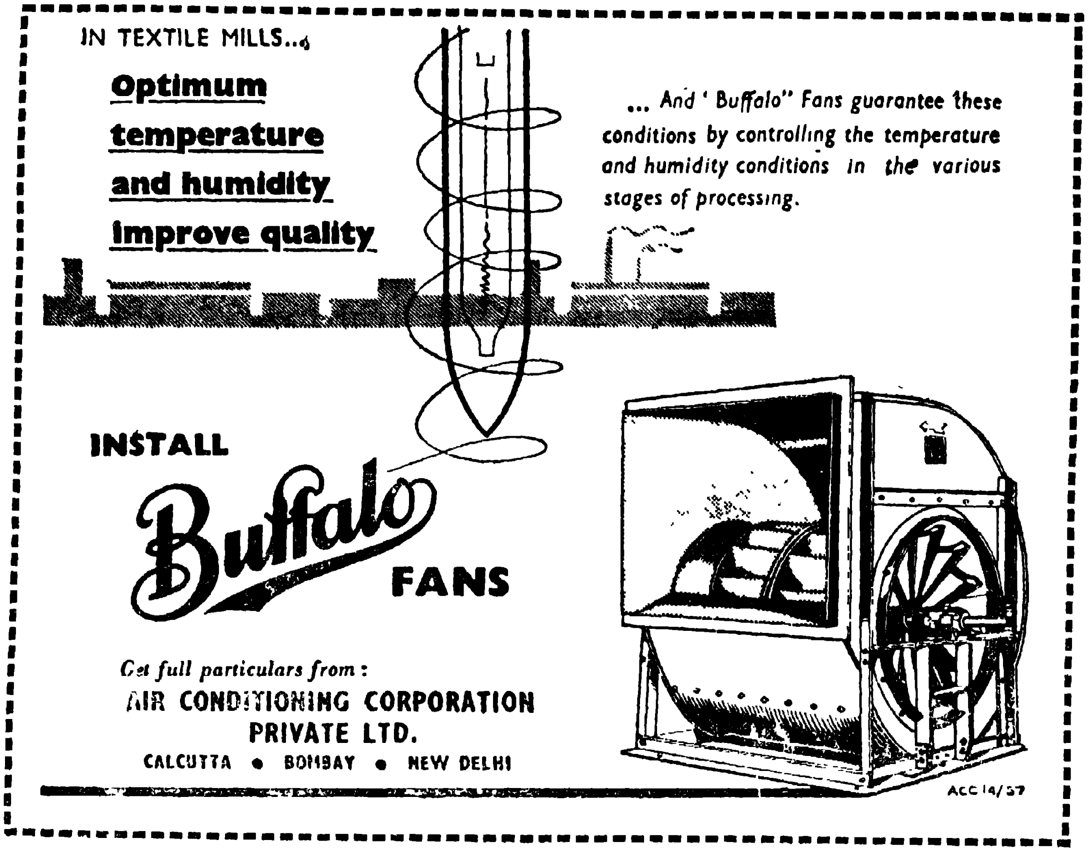

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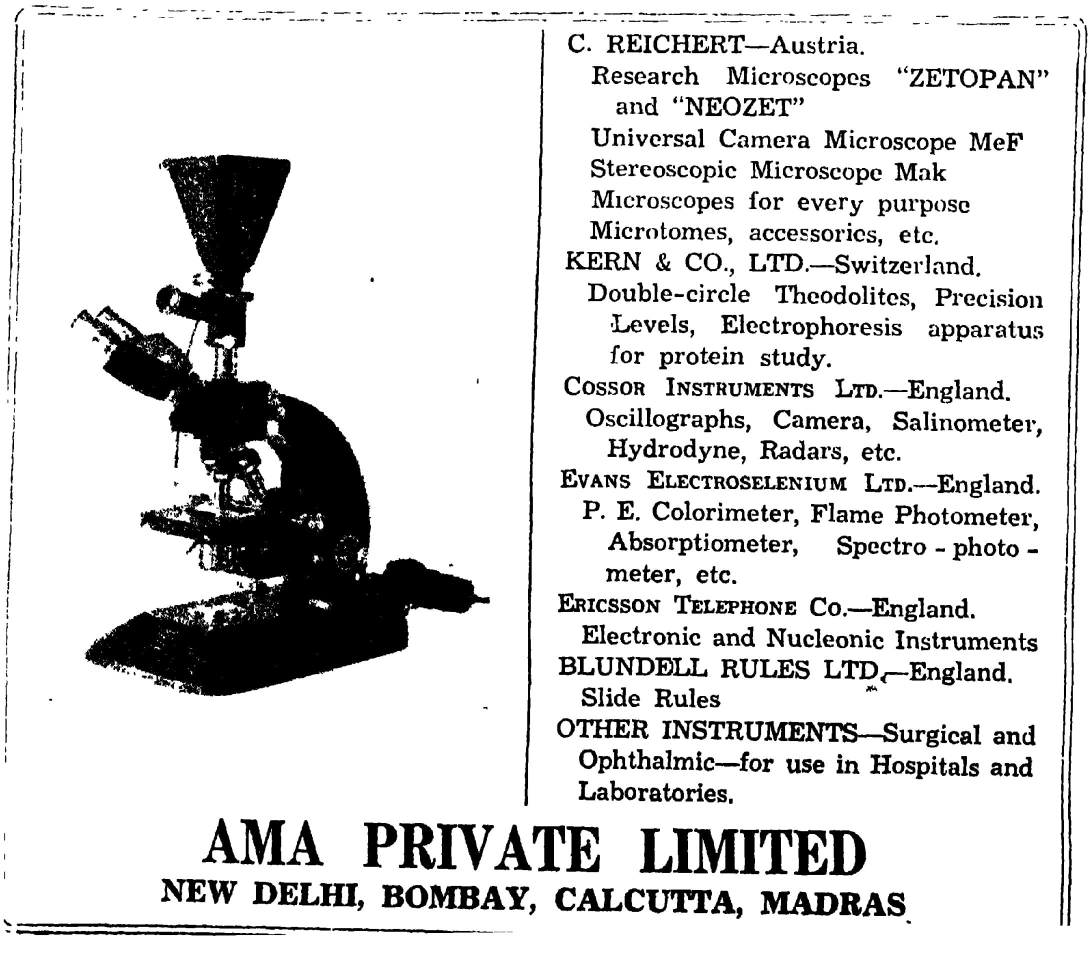

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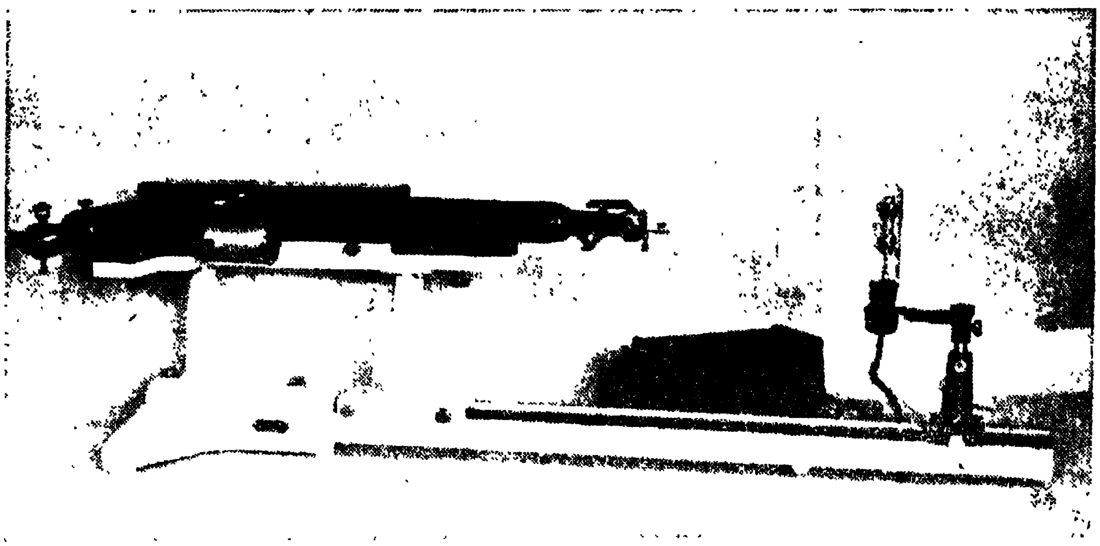

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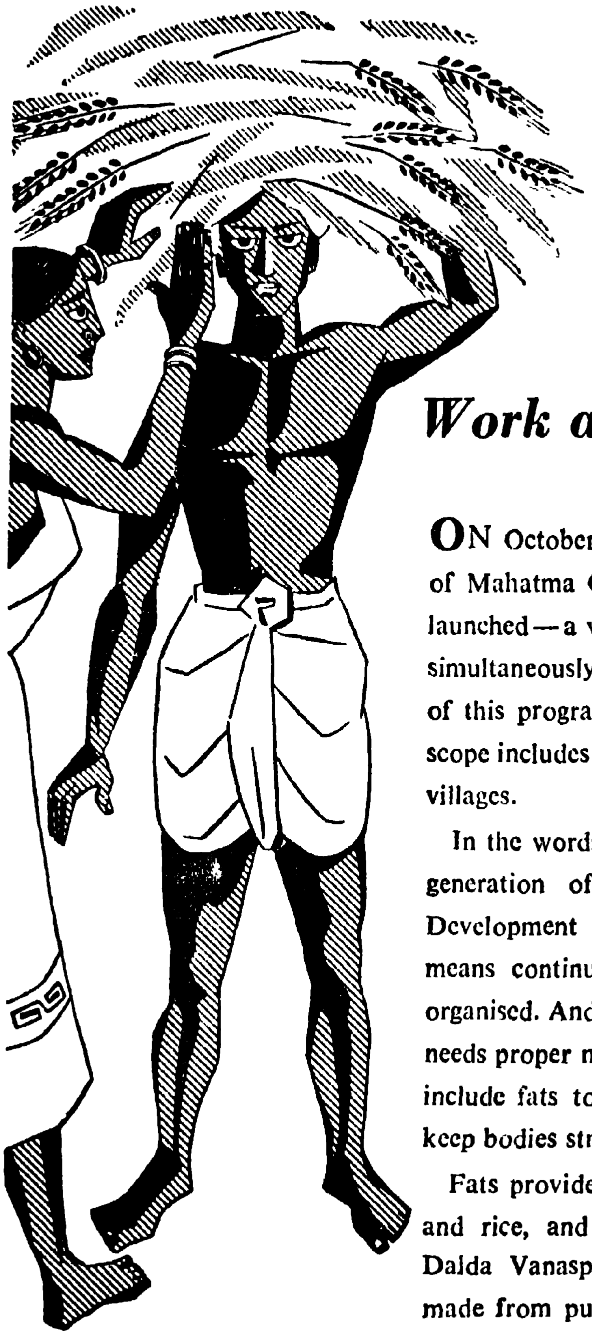

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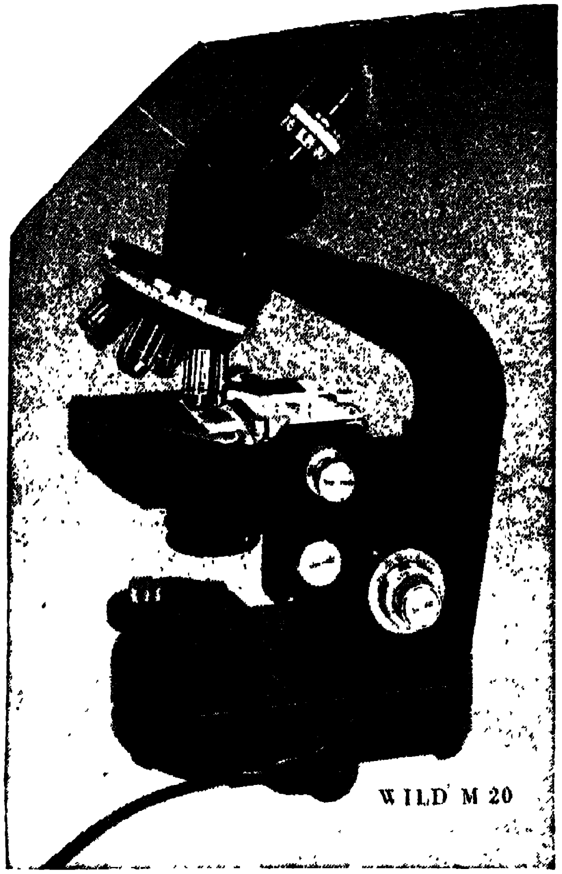

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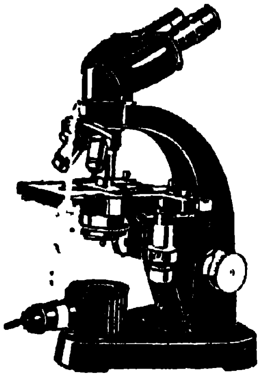

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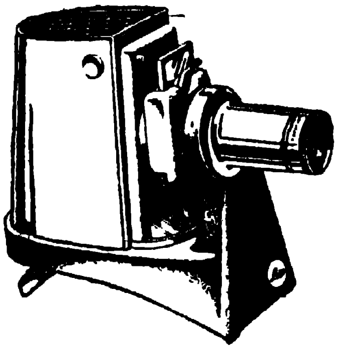

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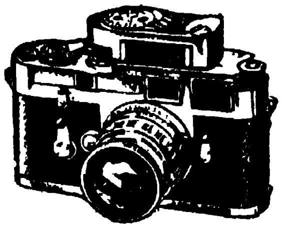

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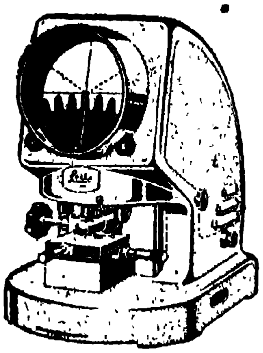

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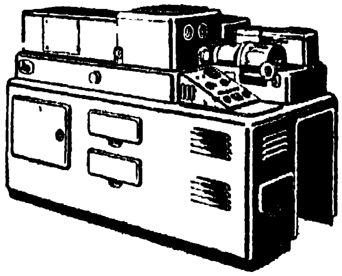

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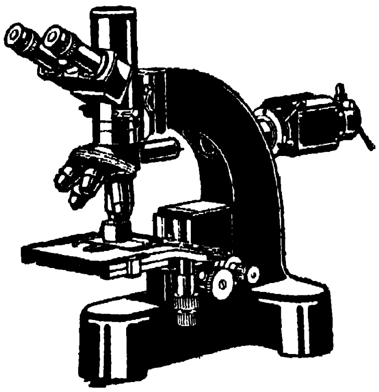

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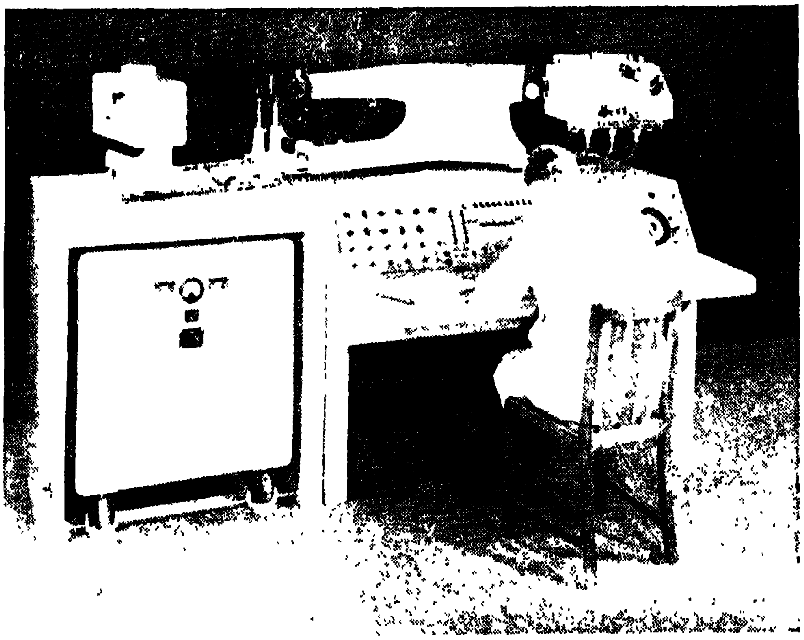

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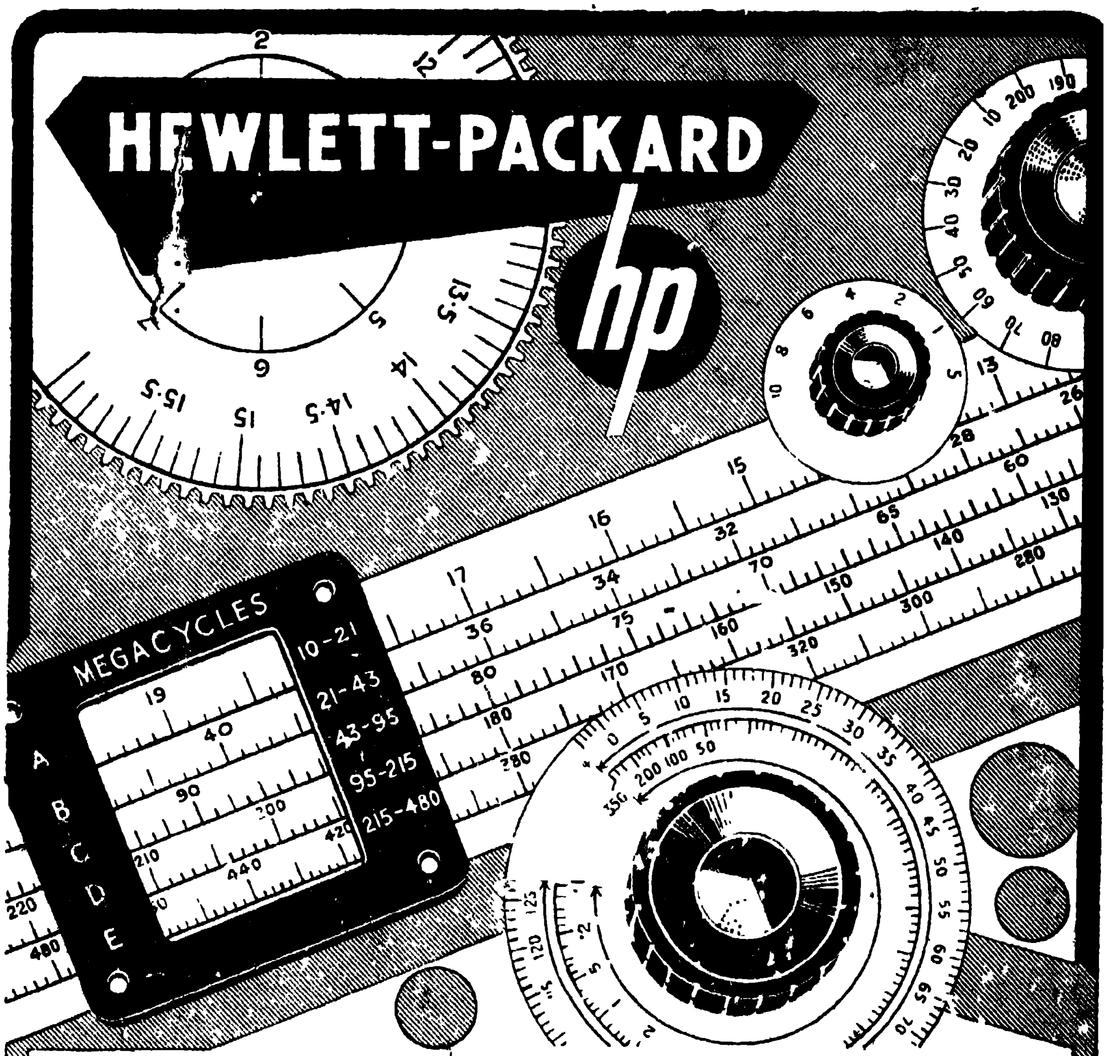

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